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FISHERIES SCIENCE CENTER

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ANTARCTIC ECOSYSTEM RESEARCH GROUP

La Jolla, California

Working Group Meets on Fish Stock Assessment

The Scientific Committee (SC) of the Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR) has established a permanent Working Group on Fish Stock Assessment (WG-FSA). The group meets each year to prepare reports for the use of the SC and ultimately the Commission of CCAMLR on the status of commercially targeted fish. This year the WG-FSA meeting was held in Hobart, Australia, from October 13 to October 22, 1992. Rennie Holt, chief of the Antarctic Ecosystem Research Group (AERG), George Watters, fishery biologist of the Southwest Fisheries Science Center (SWFSC), and Robert Otto of the Alaska Fisheries Science Center attended the meeting for the U.S. delegation.

Watters presented a plan for a random stratified trawl survey designed to assess the status of commercially important finfish stocks in the Antarctic Peninsula area; the initiative was well received by the group. The survey will include 100 stations stratified according to three depth zones, and it is hoped to be accomplished aboard a Russian fishing vessel. If coordination with a Russian fishing vessel can be accomplished in time for the upcoming fishing season, the survey will be conducted between January and late March 1993. After reviewing the details of the plan, the WG-FSA made recommendations for improving the survey design. In addition to Russia, scientists from Poland, Germany, and Chile expressed interest in participating in the survey.

The U.S. fishing vessel *Pro Surveyor* conducted fishing operations for Antarctic crabs in waters surrounding South Georgia Island and Shag Rocks from July 10 to August 1, 1992. This is the first time Antarctic crabs have been harvested by a commercial fishing operation. In keeping with CCAMLR's requirement that all new fisheries provide data necessary to assess the status of the resource, Otto, who served as an observer of the fishing operations, presented a paper describing the new fishery and some preliminary results from studies on Antarctic crab maturity, parasitism, and size frequency.

Using data collected during the fishing operations, Otto reported that two crab species were caught: *Paralomis spinosissima* and *P. formosa*, with *P. spinosissima* being the major target species. Lines of 50 to 60 crab pots were used for all fishing. Crabs retained by the fishery were male *P. spinosissima* that exceeded 102 mm in carapace width. The WG-FSA, using data provided by the United States, made a preliminary estimate of the standing stock of commercially sized male *P. spinosissima* at 155,000 metric tons.

The WG-FSA spent considerable time formulating recommendations for the Scientific Committee on the management of the crab fishery. It was agreed that pending the development of a long-term management plan for the crab fishery, short-term precautionary measures should be applied. These measures include the following:

- (1) The crab fishery should be limited to only sexually mature males. (For the *P. spinosissima*, the carapace would need to be at least 102 mm. For the *P. formosa*, it would need to be at least 90 mm.) In this way, it is hoped that the males can spawn at least once before they become vulnerable to the fishery. Also, all female and undersized male crabs should be released unharmed.
- (2) Crab fishing gear should be limited to the use of crab pots; all other methods (e.g., bottom trawls) should be prohibited.
- (3) Data from the fishery should be collected and delivered to CCAMLR before the next meeting of the WG-FSA.
- (4) The exploratory crab fishery should be limited to one vessel per country; however, if CCAMLR is notified that more than three vessels (from all countries combined) intend to fish for crab, no more than 1600 metric tons of crab shall be taken.
- (5) New fishing vessels intending to participate in the fishery should register with CCAMLR at least 3 months prior to fishing operations.

In regard to a long-term management plan, it was agreed that a workshop should be convened to consider alternative methods for stock assessment and collection of pertinent data. The workshop is planned to be held at the SWFSC in La Jolla in late April or early May 1993. (J. Rosenberg, [619] 546-5600)

COASTAL FISHERIES RESOURCES DIVISION

La Jolla, California

Report Completed on Mexican Sportfish Economic Survey

Cynthia Thomson, industry economist at Southwest Fisheries Science Center (SWFSC), and Santiago Gomez of the Mexican Department of Fisheries have completed a 278-page report entitled "Results of the Mexican sportfish economic survey" (NOAA Technical Memorandum NOAA-TM-NMFS-SWFSC-173). The report describes results of a survey of U.S. anglers who fished in Mexican territorial waters in the Pacific Ocean and Gulf of California (Sea of Cortez) during 1991. The purpose of the survey was to obtain baseline information on boat-based fishing activity, harvest by species, fishing expenditures, angler demographics and fishing patterns of angling households. The survey was conducted by the Government of Mexico, Department of Fisheries, San Diego, California, with technical assistance from the National Marine Fisheries Service, SWFSC, La Jolla, California.

Potential respondents for the survey were drawn from license application files maintained by the Mexican Department of Fisheries. Of the 4,567 questionnaires originally mailed, 170 were returned as undeliverable, 1,879 were not returned, and 2,518 were completed and returned. Estimates of aggregate fishing effort, harvest, and expenditures were obtained by extrapolating from the survey sample to the population of license holders in 1991. These extrapolations likely underestimate effort, catch, and expenditures in a "typical" year for the following reasons: (1) some individuals may engage in boat-based fishing activities in Mexican waters without a license; and (2) the number of licenses issued was significantly lower than average in 1991.

About 44,673 American anglers from 27,812 households fished from boats in Mexican waters during 1991. Slightly more than one-half of these households and anglers fished exclusively from commercial passenger fishing vessels (CPFV). The CPFVs transport paying passengers between a San Diego port and fishing grounds in Mexico. They provide bait, food and beverages, gear rental, fish cleaning, and other services and are generally operated by a skipper with marine sportfishing expertise. The rest of the households and anglers fished

in either non-CPFV modes only or in both CPFV and non-CPFV modes. A total of 102,435 household trips (146,577 angler trips) was made during the year. About 43 percent of total trips were one-day/overnight CPFV trips, 19 percent were trips aboard private boats launched from the United States, and 18 percent were trips aboard private boats cartop-carried or trailered from the United States to Mexico. An additional 8 percent were multi-day CPFV trips; 8 percent were trips aboard pangas (outboard powered skiffs) and cruisers (larger powered vessels)--both are chartered in Mexico with a Mexican guide; and 4 percent were trips aboard boats owned by Americans but moored in Mexico.

Many questions in the survey pertained to the "key angler" in the household, that is, the household member who made the most fishing trips to Mexican waters in the previous year. Key anglers possessed a distinctive demographic profile. About 95 percent were male. About 86 percent were non-Hispanic White, with most of the remainder about evenly split between Asians and Hispanics. Over 38 percent of key anglers possessed a four-year college degree. Median household income was \$50,000-\$60,000 per year. About one-half of the key anglers were employed in a managerial or professional position and 18 percent were retired. The key angler was, on average, 46 years of age, had 22 years of saltwater fishing experience, and began fishing in Mexican waters at the age of 31 years. The key angler appeared to set the household's fishing patterns. Although he/she sometimes fished in Mexico without other household members, other members seldom fished there without the key angler.

Survey results indicate that about 820,912 fish were caught in Mexican waters in 1991 by boat-based anglers. Cabrilla, rockfish, yellowfin and other tunas, bonito/barracuda/bass, dorado, and yellowtail together accounted for over 60 percent of total harvest. About 42 percent of total harvest was made from cartop-carried/trailered boats, 29 percent from CPFVs (one-day trips), 9 percent from CPFVs (multi-day trips), 9 percent from pangas/cruisers, 9 percent from private boats launched in the United States, and 3 percent from private boats moored in Mexico.

About 285,751 (35 percent) of the 820,912 fish caught in 1991 were subsequently released. The release rate tended to be lower for one-day CPFVs, multi-day CPFVs, and panga/cruiser trips (22 percent-28 percent) than for cartop-carried/trailered

boat trips and trips from private boats launched from the United States or moored in Mexico (36 percent-44 percent). Release rates also varied by species, ranging from a high of 65 percent-70 percent for marlin, sailfish, and roosterfish to below 25 percent for more commonly caught species like yellowfin, other tunas, yellowtail, and rockfish.

Expenditures for trips in all fishing modes totaled \$79 million in 1991. About 24 percent of these expenditures were generated by trips aboard car-top-carried/trailer boats. Private boat trips launched from the United States, one-day CPFVs, multi-day CPFVs, and panga/cruiser trips each contributed about 14 percent-20 percent. Trips aboard private boats moored in Mexico contributed about 9 percent of total expenditures. These expenditure estimates include items such as airfare, car rental, own automobile mileage costs, lodging, food and beverages, fishing gear and tackle, CPFVs, panga and cruiser fees, bait, licenses, tips, and fish preparation (e.g., canning, filleting, smoking, packaging, freezing, shipping, and mounting). (C. Thomson, [619] 546-7116)

Pelagic Fishery Management Options Adopted

The Pacific Fishery Management Council is developing a new Fishery Management Plan (FMP) for coastal pelagics species (CPS), which includes northern anchovy, Pacific mackerel, Pacific sardine and jack mackerel. Management options for the FMP are being developed by the Coastal Pelagics FMP Development Team and Advisory Subpanel with input from interested parties. The FMP Development Team consists of biologists and economists from the Southwest Fisheries Science Center and California Department of Fish and Game. The Advisory Subpanel consists of industry representatives.

Council has decided to consider options for managing the fishery via open access and license limitation but not individual transferable quotas (ITQs), with the understanding that a license limitation program could be converted to an ITQ system at a later date. Council has also designated January 1, 1986 - November 13, 1991 as the "window period" (i.e., the time frame during which a vessel must have made a minimum specified level of landings to qualify for a limited entry permit), and has decided to allow vessels to qualify for a permit on the basis of squid as well as CPS landings. Many of California's squid boats participated in (or are the

"descendants" of boats that participated in) the sardine fishery during its heyday in the 1940s and 1950s.

Council has endorsed the Team's concept of a two-tiered permit system, with vessels landing some designated minimum amount of CPS and/or squid during the window period receiving a "small boat" permit and vessels landing some greater designated minimum amount of CPS and/or squid during the window period receiving a "large boat" permit; the exact levels of landings needed to qualify for small and large boat permits have not yet been decided. Small boat permit holders would also be subject to a trip limit of 10 t of CPS per trip. This two-tiered system accommodates vessels that serve low volume segments of the fishery (e.g., fresh fish markets) as well as high-volume producers. The permits would be transferable.

Council has decided to issue conditional permits to boats displaced by the California Marine Resources Protection Act (Proposition 132). This option would allow gill and trammel net fishers who purchased 1991 Marine Resources Protection Act permits from the State of California to obtain conditional CPS fishery permits that could be converted to permanent small boat permits after one year of CPS fishing. Conditional permits would be issued on January 1, 1994, when the gillnet fishery becomes illegal. Minimum CPS landings, minimum CPS trips, a fee to cover administrative costs and, possibly, an inspection of the vessel would be used as a basis for converting conditional permits to permanent small boat permits. In order to discourage fishers from obtaining permits for speculative purposes, permanent permits might be made nontransferable for two years.

Council has decided to exempt the following CPS harvests from license limitation requirements:

- (1) incidental commercial catches of CPS (one t or less per trip). Incidental CPS landings comprised about 13 percent of total CPS trips but less than 0.3 percent of total CPS landings during the window period. The purpose of this action is to discourage discard of CPS taken incidentally in small quantities.
- (2) harvest of CPS for use as live bait in the recreational fishery. About 5,000 t of CPS (mostly anchovy) are harvested annually for use as live bait. The purpose of this action is to ensure that no resources are expended to manage fishing effort

within this small, market-limited segment of the CPS fishery.

- (3) recreational harvest of CPS. Pacific mackerel are the only CPS often taken by anglers (average 1,462 t per year). The purpose of this action is to ensure that no resources are expended to manage fishing effort in the recreational fishery, where the total catch of CPS is small and effort management would be difficult.

In recent years several factory trawlers have attempted (thus far unsuccessfully) to find commercial quantities of the underutilized jack mackerel resource. Should the Council decide to manage CPS via limited entry system, future attempts by these factory trawlers to develop the jack mackerel fishery would be limited since none of these trawlers would qualify for a limited entry permit on the basis of CPS landings during the window period. In order to allow for orderly development of the jack mackerel fishery, Council has endorsed an experimental permit system to manage fishing effort directed at underutilized species. These experimental permits would be issued on a year-to-year basis; permit holders could also be required to abide by restrictions on gear and geographic range of operations, provide harvest data and carry an observer on board. Council has also indicated that vessels involved in developing a fishery for underutilized species would receive first priority for permanent entry into the fishery if and when additional limited entry permits were to be issued as a result of fishery development.

Council is also considering whether or not to impose license limitation requirements on fishing effort north of 39° N latitude (approximately Point Arena). While CPS are normally concentrated south of Point Arena, they tend to expand their range northward during periods of high biomass. At issue here is whether, in the absence of such licensing requirements, overcapitalization would likely occur in northern areas if fishing opportunities for CPS (most notably sardine and jack mackerel) were to develop in those areas. (L. Jacobson, [619] 546-7116).

Symposium on Larval Fish Assemblages Is in Press

The editing of a volume of papers delivered at a symposium entitled "Larval fish assemblages and oceanic boundaries" has been completed, and the papers will be published in the Science Series of the Natural History Museum of Los Angeles County.

The symposium was a plenary session of the 15th Annual Larval Fish Conference, sponsored by the Early Life History Section of the American Fisheries Society in Los Angeles, California, June 1991. The symposium was organized by Fishery Biologists H. Geoffrey Moser and Paul E. Smith, who completed the scientific editing last May. Technical editing of the volume has now been completed by Dr. Lee Fuiman, editor of the Early Life History Section.

A principal objective of the symposium was to review what is known about the composition and structure of larval fish assemblages in the world ocean and present the results of current research on these assemblages. Another focus of the symposium was the relation of larval fish assemblages to the environment. The symposium proceedings will include 12 papers, contributed by 28 authors. The contributors represented 8 countries and, among the U.S. contingent, all National Marine Fisheries Service Science Centers were represented by a total of 13 contributors. The following is a list of the authors and titles of the papers in the order in which they will appear in the volume:

Edward D. Houde and Colleen E. Zastrow. Ecosystem and taxa-specific dynamic and energetics properties of fish larvae assemblages.

George W. Boehlert and Bruce C. Mundy. Ichthyoplankton assemblages at seamounts and oceanic islands.

Jeffrey M. Leis. Larval fish assemblages near Indo-Pacific coral reefs.

Michael J. Kingsford. Biotic and abiotic structure in the pelagic environment: importance to small fish.

Valerie J. Loeb, Adolf K. Kellerman, Phillippe Koubbi, Anthony W. North, and Martin G. White. Antarctic larval fish assemblages: a review.

M. Pilar Olivar and Peter A. Shelton. Larval fish assemblages of the Benguela Current.

William J. Richards, Michael F. McGowan, Thomas Leming, John T. Lamkin, and Sharon Kelley. Larval fish assemblages at the Loop Current Boundary in the Gulf of Mexico.

John J. Govoni. Flux of larval fishes across frontal boundaries: examples from the Mississippi River plume front and the western Gulf Stream front in winter.

Robert K. Cowen, Jonathan A. Hare, and Michael P. Fahay. Beyond hydrography: can physical proc-

esses explain larval fish assemblages within the Middle Atlantic Bight?

Miriam J. Doyle, Wallace W. Morse, and Arthur W. Kendall, Jr. A comparison of larval fish assemblages in the temperate zone of the northeast Pacific and northwest Atlantic.

H. Geoffrey Moser and Paul E. Smith. Larval fish assemblages of the California Current region and their horizontal and vertical distributions across a front.

Gerald E. McGowen. Coastal ichthyoplankton assemblages, with emphasis on the southern California Bight.

The symposium contributors accomplished the primary goal of bringing together and summarizing what is known about larval fish assemblages. The 12 papers revealed a large and growing information base for most regions of the world ocean and indicate that we can begin to address the fundamental questions pertaining to these assemblages. (H. G. Moser, [619] 546-7129 and P. E. Smith, [619] 546-7169)

MARINE MAMMAL DIVISION

La Jolla, California

DOLPHIN STOCK ASSESSMENT PROGRAM

Survey Completed to Assess Status of Central Stock of Common Dolphin

On November 2, 1992, two NOAA research vessels, *David Starr Jordan* and *McArthur*, completed a 3-month survey of the area inhabited by the central stock of common dolphin, *Delphinus delphis*. During this year's Population of *Delphinus* Stocks (PODS) survey, Southwest Fisheries Science Center (SWFSC) scientists were responsible for collecting information on the density, size, and species composition of marine mammal schools encountered in the eastern tropical Pacific Ocean. The primary purpose of the cruise, which began in San Diego July 28, 1992, was to collect data to estimate the population size of the central stock of common dolphins. Data from observers on tuna vessels have indicated that this stock of dolphins may have been severely reduced as a result of incidental mortality

in tuna purse seines. Marine mammal surveys conducted in past years have permitted only very imprecise estimates of population size for this stock.

Marine Mammal Surveys

The ships covered approximately a 650,000-nm² study area off Central America where common dolphins have been seen in the past. The primary grid of northeast/southwest transects was completed, and the secondary grid of northwest/southeast transects was nearly completed. A total of 11,023 nm of trackline was covered with full survey effort in the study area.

The surveys were conducted by maintaining a visual watch on each vessel using two 25-power binoculars with a maximum ship-to-horizon sighting distance of approximately 6 nautical miles. Generally, all schools encountered within 3 nautical miles were approached to confirm identification and obtain school size estimates (Fig. 1). Overall there were 1326 sightings of cetaceans among 37 different species or species groups (Table 1, page 6). The data will be analyzed by line-transect methods to produce estimates of abundance for common dolphins and other species.



Figure 1. School of dolphins off the coast of Mexico during the 1992 Population of *Delphinus* Stocks survey.

During the transit along the coast of Mexico to and from the study area, SWFSC scientists collected data, including photographs, that will aid in defining marine mammal stock boundaries. Individual whales can be recognized from photographs of dorsal fins, tail flukes, and body color patterns. Photographs taken on this cruise will contribute to a

Table 1. Number of schools of various species or species groups seen during the 1992 Population of *Delphinus* Stocks survey.

Species	Number of sightings
DOLPHINS	
Offshore spotted	118
Coastal spotted	23
Eastern spinner	42
Whitebelly spinner	7
Central Amer. spinner	4
Striped	155
Rough-toothed	27
Long-beaked common	46
Short-beaked common	101
Bottlenose	129
Risso's	45
Pacific white-sided	14
Unidentified spinner	5
Unidentified common	12
Unidentified spotted	23
Unidentified	194
WHALES	
Bryde's	15
Sei/Bryde's	21
Blue	10
Humpback	12
Pilot	38
Killer	4
False killer	2
Pygmy killer	2
Melon-headed	2
<i>Feresa/Peponocephala</i>	2
Sperm	41
Dwarf sperm	12
Ziphiid	9
<i>Z. cavirostris</i>	6
<i>Mesoplodon</i> spp.	9
<i>Berardius</i> sp.	5
Unidentified small	21
Unidentified large	23
Unidentified baleen	16
Unidentified	4
Other	8

growing catalog of individually known blue and humpback whales along the Pacific coast. Resightings of known animals can produce the same kinds of information on movement, mortality rates, birth rates, and population size that resightings of numbered tags do. (T. Gerrodette, [619] 546-7131)

Dolphin Ecology

During the PODs cruise, data were also collected on dolphin habitat in the eastern tropical Pacific study area and on associated pelagic species such as birds, turtles, and fish eggs and larvae. Oceanographic data collected during daylight survey operations included continuous surface temperature and salinity, discrete surface chlorophyll every 2 hours, and vertical temperature profiles every 3 hours. A total of 519 temperature profiles was obtained by XBT and by mini-CTD. At morning, CTD stations, temperature, and salinity were measured to 1000 m and water samples were collected for chlorophyll, nutrient, and primary productivity measurements. A total of 117 stations was occupied, 1916 chlorophyll samples were analyzed, and 917 estimates of primary productivity by ^{14}C -uptake were completed. These results will be used in an analysis of habitat variability to help interpret the dolphin abundance estimates and to describe spatial patterns of oceanographic processes in an undersampled region of the eastern tropical Pacific.

A total of 80 turtles was captured, measured, and returned to the ocean. Blood samples were obtained from 64 of these turtles, and 77 were tagged. On the third leg of the cruise, the Inter-American Tropical Tuna Commission conducted larval tuna sampling in the Panama Bight. Nighttime dipnet stations for surface nekton and Manta tows for fish eggs and larvae were conducted on both ships during all three legs. The flying fish taxonomy of the tropical Pacific is under revision as a result of this continuing effort, which has been carried out over the years—mainly by Robert Pitman, biological technician. The SWFSC also has a unique set of surface samples covering an immense area in the eastern tropical Pacific Ocean. Observations of seabirds were carried out during all daylight hours. (P. Fiedler, [619] 546-7016)

Biological Assessment

SWFSC scientists on the PODs cruise also collected skin biopsy samples from dolphins to aid in defining stock structure and boundaries. Samples were taken from animals that approached the vessel to bow ride. A scientist, stationed at the bow of the vessel, used a cross bow—firing a bolt with a small, hollow tip and a retrieving line, to obtain a tiny piece of tissue from the back of the animal. In general, the procedure did not cause the animals to halt their bow ride. On the 1992 cruise, tissues were collected from 40 spotted dolphins, 10 spinner dolphins, 30 bottlenose dolphins, 25 common dol-

phins, 4 Pacific white-sided dolphins, and 2 rough-toothed dolphins.

The tissues will be analyzed for genetic differences using a standard, well-established DNA procedure. Briefly, the procedure first involves extraction of the total cell component of DNA (nuclear and extra-nuclear) from the tissue. The DNA segment desired for analysis (approximately 500 base pairs) is isolated and amplified to high concentrations using the polymerase chain reaction (PCR). This is an amazing procedure considering that the ratio of desired DNA to the rest of the DNA is less than 1 in 10,000. The amplified segment is analyzed to determine the sequence of nucleotide bases (abbreviated A,C,G, or T) that constitutes the genetic signature of the particular animal. The animals' sequences are then analyzed using computer programs that determine the degree of relatedness between individuals. Besides revealing existence of reproductively isolated populations (stocks) and evolutionary lineages, recently developed methodologies allow estimation of gene flow between lineages and average dispersal distances per generation. (A. Dizon, [619] 546-7089)

Photogrammetry

Aerial photogrammetry was conducted from a Hughes 500D helicopter launched from the research vessel *David Starr Jordan*. This year was the first field test of a new set of reconnaissance cameras that are much more reliable and that provide exceptionally high resolution. The aerial photographs provide several unique kinds of information:

- (1) Air-truthing of dolphin school size. Estimates of school size made by observers aboard both vessels will be calibrated against counts from aerial photographs. This reveals, and allows correction for, tendencies to over- or underestimate school size, thus providing more accurate estimates of dolphin population size. This year 120 dolphin schools were photographed and of these, 55 photographs were suitable for school size calibration.
- (2) Length frequency distributions of cetaceans. Because photographs are taken vertically and with such high resolution, lengths of dolphins and whales can be accurately determined. This year the focus was on common dolphins, and the SWFSC researchers successfully photographed schools of at least four different stocks of this species. Measurements from the aerial photographs will be used to identify possible differences in average body size among these stocks.
- (3) Pinniped colony photographs. In a cooperative study with Mexican scientists, aerial photographs were taken of California sea lion rookeries along the Pacific coast of Baja California, Mexico. Pupping locations, number of pups, and population size can be determined from these photographs.

To complement the aerial photogrammetry, shipboard photographs were taken to document dolphin body morphology and color patterns, which are known to vary from on- to offshore. (W. Perryman, [619] 546-7014).

DOLPHIN-SAFE RESEARCH PROGRAM

Dolphin-Safe Research Cruise to Begin

On November 6, 1992, the dolphin-safe research project in the eastern tropical Pacific Ocean will commence. Using dolphin-safe research funds allocated by the U.S. Congress and ship charter funds from NOAA, the NOAA research vessel *McArthur* and the commercial tuna purse-seiner *Nicole K* will embark upon a combined research effort directed toward developing a better understanding of the tuna-dolphin associations characteristic of this area. The primary goal of the research program is to collect information that will aid in developing methods of catching large yellowfin tuna in the eastern tropical Pacific Ocean without endangering the dolphins that often occur in association with these fish.

This unique project, conducted as a cooperative study between National Marine Fisheries Service and the Inter-American Tropical Tuna Commission (IATTC), comprises three related research objectives: (1) simultaneous electronic tracking of tunas and dolphins captured in single sets, (2) behavioral observations of bird flocks associated with feeding aggregations of tuna and dolphins, and (3) food habits of tunas and other biota associated with floating objects.

The tracking studies will examine the temporal and spatial extent of tuna-dolphin associations. In particular, researchers hope to discover whether the association breaks down at night. If so, then night fishing might prove a promising dolphin-safe alternative to the current practice of purse-seining only during the day. Researchers plan to capture up to three tuna-dolphin associations. From each association captured, several tuna will be tagged with sonic tags and several dolphins will be tagged with radio tags. Researchers will then follow the tagged animals as long as possible, using tracking

equipment installed on *McArthur's* hydrographic launches and in the tuna seiner's helicopter.

The bird flocking behavior (species composition and persistence, daily variation in flock size, behavior within and without feeding aggregations) associated with the tuna-dolphin aggregations will be examined for clues for locating and identifying tuna schools with and without associated dolphins, in hopes of developing alternative sighting cues to large yellowfin.

The food habits study will complement a similar study (conducted by IATTC) of food habits of dolphin-associated and schoolfish tuna, collected from the commercial fishery. The dolphin-safe research cruise will provide an unusual opportunity to sample unlimited stomachs from log-associated fish, including non-tunas such as billfish and sharks. On commercial seiners, time and space constraints usually preclude collecting such samples.

The tracking portion of the research project will entail three weeks, after which time *McArthur* must return to home port. The tuna seiner will continue to fish for up to 45 days, providing up to an additional 3 weeks to collect flocking and feeding data.

Each of these three research projects has been proposed repeatedly for many years; combining the services of a commercial seiner with those of an oceanographic research vessel provides the first opportunity to actually carry them out. Researchers are optimistic that the results from this unique joint venture will contribute significantly to understanding of the tuna-dolphin bond. (E. Edwards, [619] 546-7099).

DOLPHIN ECOLOGY PROGRAM

Habitat Variability Studied with Color Scanner Data

Seasonal and interannual variability of habitat quality are important considerations in monitoring dolphin stocks in the eastern tropical Pacific (ETP). Habitat variability determines whether survey coverage of a putative species or stock range is adequate to produce an accurate population estimate. It may also contribute to long-term population changes. One component of habitat quality is primary production, which ultimately determines food availability even for top predators. A series of global monthly composites of phytoplankton pigment concentration estimated from Coastal Zone Color Scanner (CZCS) data, collected from November 1978 through June 1986, was obtained from NASA. Oceanographer Paul Fiedler, with the help of Lt. John Steger, of the NOAA Corps, extracted

time series of mean monthly pigment concentration in relatively well-sampled regions of the ETP. The regions are 250,000 to 980,000 km² in area.

Four 92-month time series of mean phytoplankton pigment concentration are plotted in Figure 2. Interannual variability of pigment concentration is dominated by the 1982-1983 El Niño event. Mean pigment concentration declined during this period by 42-50 percent in coastal upwelling regions at the Gulf of Tehuantepec, the Costa Rica Dome, and Ecuador. The decline was only 27 percent in the equatorial upwelling region around the Galapagos. Primary production is reduced in the ETP during El Niño events: anomalous deepening of the thermocline reduces mixing and advection of nutrient-rich deep water into the surface layer.

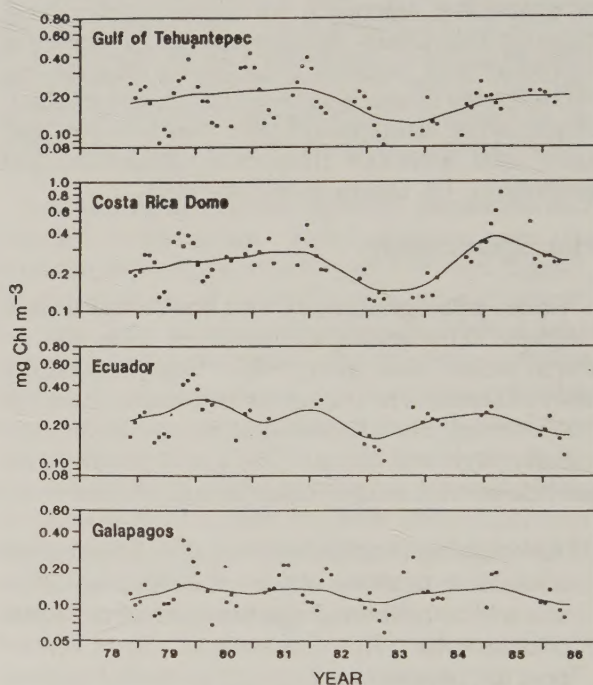


Figure 2. Monthly mean Coastal Zone Color Scanner phytoplankton pigment concentration (mg Chl m⁻³) in four upwelling regions of the eastern tropical Pacific, November 1978 - June 1986. Solid lines represent double 13-month running means.

Seasonal variability of mean phytoplankton pigment concentration is illustrated in Figure 3. Seasonal minima occur in April-August. Seasonal maxima of 1.7-2.7x the minima occur in September-November. The largest seasonal signal is observed in the Gulf of Tehuantepec, where strong northerly winds across the isthmus force surface water offshore during winter. This results in upwelling of nutrient-rich subsurface water. The fall-winter

peak in the three other regions is associated with seasonally strong trade winds that drive coastal and equatorial upwelling.

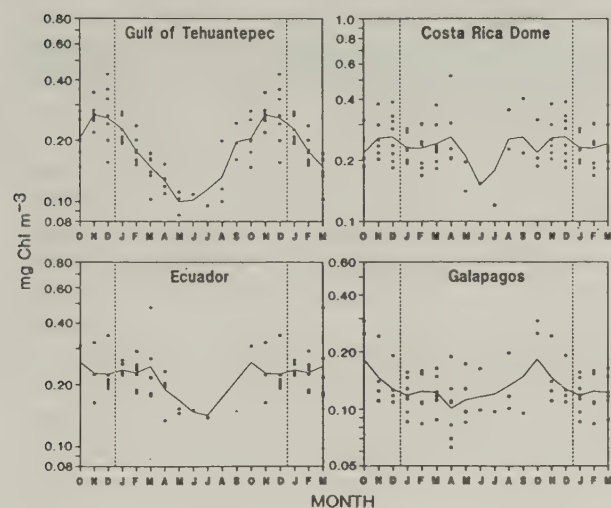


Figure 3. Seasonal cycles of monthly mean Coastal Zone Color Scanner phytoplankton pigment concentration (mg Chl m^{-3}). Interannual variability has been removed by subtracting the difference between the double 13-month running mean and the overall mean. Solid lines represent monthly means, except where $n < 3$ a 3-month weighted mean (1-2-1) is used.

Seasonal variability exceeds interannual variability only at the Gulf of Tehuantepec (Table 2). Interannual variability is apparently stronger along the equator and at the Costa Rica Dome. This result may be an artifact of the occurrence of one of the strongest El Niño events of the century during the

Table 2. Seasonal and interannual variance of Coastal Zone Color Scanner phytoplankton pigment concentration, November 1978 - June 1986, in four upwelling regions of the eastern tropical Pacific. Seasonal amplitude = maximum/minimum. Seasonal and interannual component = fraction of total variance of monthly mean pigment concentration explained by monthly means and double 13-month running means (Figs. 2 and 3).

	Seasonal Amplitude	Seasonal Component	Interannual Component
Gulf of Tehuantepec	2.72	.52	.26
Costa Rica Dome	1.65	.08	.57
Ecuador	1.70	.19	.49
Galapagos	1.82	.20	.25

time period of this study. However, shipboard surveys of the ETP detected a similar reduction in phytoplankton pigment concentration in the ETP in 1987, during the 1986-1987 El Niño event.

The results of this study will be integrated with analyses of seasonal and interannual variability in thermal structure and upwelling in the ETP (Fiedler 1992, NOAA Technical Report 109). A manuscript entitled "Seasonal variability of phytoplankton production in the eastern tropical Pacific" is in preparation. (P. Fiedler, [619] 546-7016)

COASTAL MARINE MAMMAL PROGRAM

Survey for the Endangered Vaquita Completed in the Gulf of California

As part of a cooperative agreement made at the 1992 MEXUS Pacifico meetings, Southwest Fisheries Science Center (SWFSC) Biologist Karin Forney participated in a 10-day ship survey for vaquita in the northern Gulf of California from October 19-29, 1992. East-west transects spaced at a distance of 5 minutes of latitude between $29^{\circ}20'$ and $30^{\circ}20'$ north were surveyed by this vessel. Two additional vessels simultaneously surveyed areas to the north and south of this region, providing detailed coverage of the entire northern Gulf of California south to about $28^{\circ}20'$ N latitude.

Marine mammal species sighted and identified included California sea lions, *Zalophus californianus*; long-beaked common dolphins, *Delphinus delphis*, *bairdii* type; bottlenose dolphins, *Tursiops truncatus*; pilot whales, *Globicephala* sp.; fin whales, *Balaenoptera physalus*; and sperm whales, *Physeter macrocephalus*. Additional sightings of dolphins and whales which could not be positively identified were made by all three vessels, including two probable sightings of the target species, vaquita, made by the vessel covering the northern area. This region is where most previous confirmed sightings of vaquita have been made.

The completed survey is part of a series of four, planned quarterly ship surveys for vaquita, run jointly by scientists from the Mexican Fisheries agency SEPESCA--Secretaría de Pesca (Secretariat of Fisheries)--and several universities in Mexico. The next survey is scheduled for January or February 1993, and it is expected that up to three scientists from the SWFSC will participate - one on each of the survey vessels. (K. Forney, [619] 546-7171)

Comparison Made of California Sea Lion Pup Count Methods

Counts of California sea lion, *Zalophus californianus*, pups are used to monitor the status of the California sea lion population, determine population growth rates, and estimate the size of the population. Historically, counts of pups are made by biologists walking near or through a rookery. In 1987 biologists from the SWFSC began to photograph California sea lion rookeries with a 5-inch format aerial reconnaissance camera to eliminate harassment to the animals during the census and as an alternative method for obtaining counts of these animals in inaccessible areas.

A comparison of the two methods was made at San Nicolas Island in 1992 to determine if there is a significant difference between them. A team of three biologists from SWFSC conducted a ground count of sea lion pups at San Nicolas Island on July 17-18. The biologists counted sea lions with handheld binoculars and mechanical hand counters as they walked near the rookery. Vertical color photographs were also taken on July 18 at an altitude of approximately 800 feet. Counts were made from photographs placed over a light table equipped with a binocular zoom-microscope.

Preliminary comparison of the results of the two methods indicate that the ground count was significantly less than that obtained from the photographs. The biologists on the ground counted 6,468 pups while 8,769 pups were counted from the aerial photographs. A possible reason for the discrepancy between the two counts is the difference in the field of view by a person on the ground (pups can be obscured by rocks and cliffs). The next step in the analysis will be to examine the counts by substrate (rock versus sand) and location (cliffs area versus flat exposed areas). (M. Lowry, [619] 546-7174)

California Sea Lion Prey Dynamics Analyzed

California sea lions, *Zalophus californianus*, are known to feed on a wide variety of fish and cephalopods in California waters. Dietary habits of sea lions are analyzed through the examination of scats and spewings, a messy procedure, but one that eliminates harassment and/or sacrifice of animals. Fishery Biologists Mark Lowry and Jim Carretta have been analyzing sea lion scat and spewing samples from sea lion breeding colonies at San Clemente (SCI), San Nicolas, and Santa Barbara islands. Recent data on sea lion feeding dynamics of market squid, *Loligo opalescens*, show that the size

frequency of squid consumed by sea lions throughout the year may change significantly.

In the analysis of sea lion scat and spewing samples, undigested cephalopod beaks from both octopus and squid are recovered. Morphometric measurements of these beaks can be used to reliably predict the mantle length or weight of an individual squid.

Lowry and Carretta have found that sea lions at SCI primarily feed on market squid ranging from 90 to 170 mm in mantle length, with a mean of about 150 mm. Of special note, they have found that in 1989, the size of market squid consumed by sea lions at San Clemente Island gradually increased from winter to fall (Figs. 4A-D). Lowry and Carretta are analyzing other important sea lion prey species such as northern anchovy, Pacific hake, rockfish, jack mackerel, and Pacific mackerel, with the aim of revealing year class/cohort variability

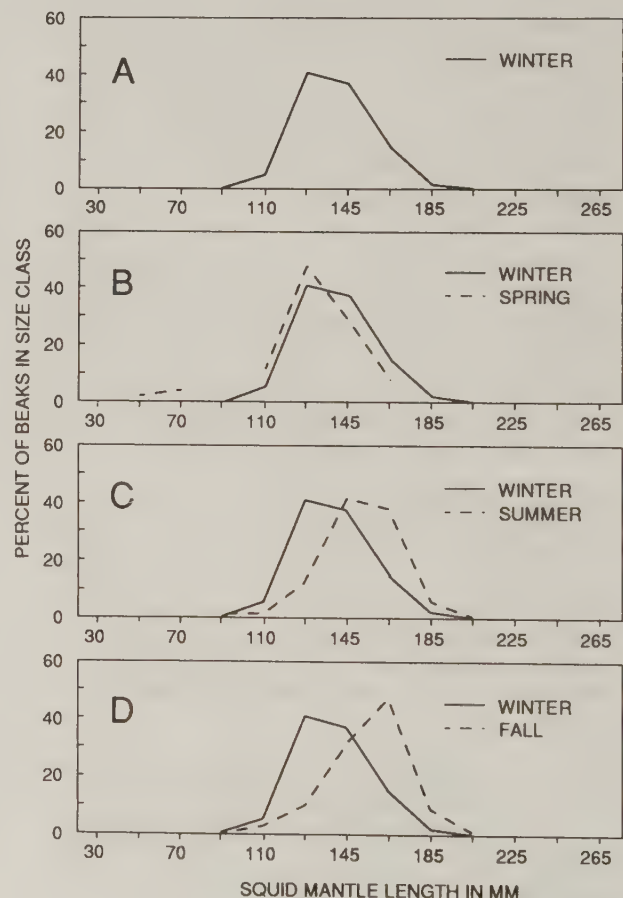


Figure 4A-D. Market squid, *Loligo opalescens*, consumed by sea lions at San Clemente Island, winter 1989 through fall/winter of the same year.

through time. A further goal of this study will be to determine the biomass of commercially important species consumed by sea lions annually. (J. Carretta, [619] 546-7181).

HONOLULU LABORATORY

Honolulu, Hawaii

PELAGIC RESOURCES INVESTIGATION

Statistical Methods Developed to Estimate Hawaiian Green Turtle Nesting Populations

After years of exploitation and population decline, Hawaiian green turtles received full protection as a threatened species under the Endangered Species Act of 1978. To promote rebuilding of the population, a provisional recovery plan for Hawaiian green turtles was prepared and is being implemented while a more comprehensive, Pacific-wide turtle recovery plan is developed. Among other actions, the plan calls for monitoring the size of the green turtle nesting population at East Island, French Frigate Shoals, which is part of the Hawaiian Islands National Wildlife Refuge. Turtles nesting at East Island account for about half the population's annual hatchling production. In 1973 a program to monitor green turtle nesting at East Island was started by George Balazs of the University of Hawaii (now a Honolulu Laboratory wildlife biologist). The surveys have been carried out each summer since. In recent years, they have been conducted by the U.S. Fish and Wildlife Service, which manages the refuge, in collaboration with the Honolulu Laboratory. The sampling protocol involves an intensive survey of East Island during a few weeks at the peak of the breeding season. Each night during the survey, turtles hauling out to nest are counted and tagged. Then the number counted over the survey period is raised to estimate the season's total nesters.

The critical part of the formula is the raising factor. This factor depends on the probability that a member of the season's nesting population hauls out to nest and is sighted during the survey period. Until recently, only sketchy information about such probabilities was available. To provide a better foundation for the estimation procedure, a series of saturation surveys was conducted at East Island during 1988-92. The saturation surveys allowed the

complete documentation of nesting activity at East Island, from its inception in May through its completion in September.

Jerry Wetherall, research fishery biologist, has recently analyzed the data collected during the 1988-91 saturation surveys (the 1992 data are not yet available). He has used them to construct a comprehensive model of nesting haul-out patterns and to develop statistical procedures for estimating the total nesting population on the basis of partial-season surveys.

Wetherall organized the haul-out information into a nesting activity matrix. Rows of the matrix contain 731 complete haul-out histories observed during the four saturation surveys. Columns of the matrix represent nights of the breeding season. If a nester was seen hauled out on a given night, the corresponding cell was assigned a value of "1"; otherwise, a value of "0" was assigned. The matrix approach leads to efficient computation of haulout probabilities and, for any partial-season survey scenario, appropriate raising factors.

Two ratio estimators of the total number of nesters were developed. Each involves a different survey statistic and raising factor. One method requires the identification of each turtle through tagging, enabling a count of the number of individual turtles hauling out during the survey (resightings are not counted). The total nesting population is estimated by dividing this count by the probability that a nester is encountered at least once during the survey. The second estimator requires only a total count of nesters hauled out during the survey, including any resightings; thus, identification of individual nesters is not essential. In the second method, the total nesting population is estimated by dividing the count by the average number of times a nester is hauled out during the survey period (termed the coverage rate). Sighting probabilities and coverage rates are estimated from the composite activity matrix and a survey schedule vector.

Bootstrap methods were developed to compute approximate confidence intervals for the total nesting population. A two-tiered algorithm was developed that accounted for (1) uncertainty in the long-term mean coverage rate or sighting probability for a specified survey schedule, and (2) within-season stochastic variation in haul-out behavior. The bootstrap analysis also provides information useful in the design of partial-season surveys. Many different survey schedules can result in the same coverage rate or sighting prob-

ability, and the latter uniquely determine estimator precision. Thus, in planning a survey, it is possible to identify an optimum survey schedule, one that satisfies requirements for statistical precision while meeting practical and budgetary constraints.

The saturation survey activity matrix also provides a wealth of information about the separate components of nesting turtle haul-out behavior. Parsing algorithms were developed to estimate arrival time distributions, nesting frequency distributions, distributions of nesting episode duration, and distributions of the inter-nesting intervals. A simulation model was built from these components as another aid to evaluating survey design alternatives.

The saturation survey results will be published. In a follow-up study, these results will be used to revise the historical series of nesting population estimates for East Island and to establish statistical procedures for monitoring population recovery. (J. Wetherall, [808] 943-1258).

Tracking of Tumored and Normal Turtles Completed

Richard Brill, George Balazs, and Kim Holland have successfully completed the data-gathering phase of a project designed to assess the effects of fibropapillomas (external tumors) on the behavior and habitat utilization of green turtles, *Chelonia mydas*, in Kaneohe Bay, Oahu, Hawaii. The project used ultrasonic depth-sensitive transmitters to monitor the dive intervals and horizontal movements of six afflicted and six healthy animals. Individuals were either followed continuously for 48 or 36 hours, then during daylight hours every other day, for an additional 12 days.

The incidence of fibropapillomas used to be rare but has increased dramatically in recent years. A majority of the turtles in Kaneohe Bay are now afflicted. Because green sea turtles are a threatened species, understanding the causes, effects, and etiology of this disease is of some urgency.

The working hypothesis behind the project was that fibropapillomas could significantly diminish the ability of turtles to dive, reduce their sustainable exercise levels, and prolong the time required to recuperate from prolonged breath-holding and bouts of strenuous exercise. These effects could, in turn, adversely influence the habitat usage, growth, and natural mortality of afflicted animals. The logic underlying this hypothesis was as follows: Fibropapillomas are highly vascularized and most

likely are not subject to the tight cardiovascular control of normal organ systems. During submergence, sea turtles (like other diving animals) conserve oxygen stores by rearranging their blood flow so that only the heart, brain, and lungs are perfused. Because it is unlikely that blood flow to fibropapillomas is subjected to any regulation, they probably continue to receive blood flow during submergence. Since cancerous tissues tend to have a weight-specific rate of oxygen consumption, afflicted animals should have a significantly diminished diving capacity.

Preliminary analysis of the data does not appear to support the original hypothesis. Afflicted turtles, on average, have longer submergence intervals than healthy individuals. The reason for this appears to be that tumored turtles are less active than the healthy individuals. The most overt behavioral difference was that tumored turtles could be easily recaptured to retrieve the ultrasonic transmitter. For reasons not yet understood, afflicted individuals could be readily approached and recaptured. Normal turtles, in contrast, would dive and swim rapidly away when the small tracking vessel approached closer than about 10 or 15 m. The reasons for this striking behavioral difference are unknown but may be a result of the fibropapillomas having a yet heretofore undescribed detrimental effect on central nervous system function. (R. Brill and G. Balazs, [808] 943-1221)

Tuna Longline Research Cruise Completed

A study of the habitat depth, hooked longevity, and vulnerability to longline fishing gear of blue marlin, *Makaira mazara*; yellowfin tuna, *Thunnus albacares*; and associated species was conducted on the NOAA ship *Townsend Cromwell* in September 1992. Time-depth recorders (TDRs) were used to keep track of the depth of longline fishing gear, while hook timers were used to measure the time at which fish were caught. Since the depth of longline gear changes during deployment, soaking, and retrieval, hook timers combined with TDRs are necessary to establish capture depth. This research was an extension of a study published this year in *Fishery Bulletin* (Boggs 1992, "Depth, capture time, and hooked longevity of longline-caught pelagic fish: timing bites of fish with chips"). Such studies are needed to understand variations in catch-per-unit (CPUE) statistics upon which fishery management advice is based. Changes in fishing depth relative to habitat depth can affect CPUE in ways that may obscure the true status of the resource.

A total of 25 sets was made, with fishing effort totaling about 13,000 hooks. The catch totaled 384 fish of 21 species, mostly non-target species such as lancetfish, *Alepisaurus ferox* (100 caught); mahimahi, *Coryphaena hippurus* (73 caught); and sharks (58 caught). Blue marlin (32 caught) were the most common billfish. The cruise was originally planned for late summer when yellowfin are most abundant. Because of the lateness of the season, yellowfin tuna, *Thunnus albacores* (12 caught); were less numerous than bigeye tuna, *T. obesus* (18 caught); or albacore, *T. alalunga* (15 caught).

Almost every hook used was equipped with a hook timer. Up to 16 TDRs were used per set (more than on previous cruises) resulting in over 300 TDR records of fishing depth. Fish were frequently caught on hooks adjacent to a TDR. These records provided data on the behavior (with respect to depth) of some fish after they were caught and confirmed (through abrupt changes in depth) some of the capture times indicated by hook timers. Hook timers indicated that fish survived many hours after being captured, with tuna tending to survive longer than billfish. Blue marlin tended to be less hardy (had shorter survival times) than striped marlin, based on striped marlin data from previous cruises.

Most tuna, billfish, and sharks were alive when captured and were released. Fifty-one fish were also tagged and released, including 6 yellowfin tuna, 8 bigeye tuna, and 22 blue marlin. Experiments also were conducted to see if longline-caught tuna could be tethered until haulback was completed and then recovered in good condition. The objective was to provide live fish that could be fitted with sonic transmitters and tracked by the same vessel that caught the fish. This method would allow tracking to be conducted in the open ocean where the small vessel normally used for tracking cannot operate. Out of seven tuna tethered, five survived in good condition. However, because of problems with the tracking equipment, no fish were tracked.

Ocean thermal structure was monitored with expendable bathythermographs (XBT) and conductivity-temperature-depth (CTD) casts with Niskin bottles for dissolved oxygen (DO) measurements. A subsurface oceanographic feature was found to have an influence on CPUE for bigeye tuna. This feature was a transition in the depth of the thermocline (18 degree isotherm) and oxycline (2 mg/L isoline) found between latitude 16.5-18°N. The thermocline rose 40 m and the oxycline rose 100 m

on the south side of the feature. Bigeye tuna were abundant along the north edge. (C. Boggs, [808] 943-1222)

PROTECTED SPECIES INVESTIGATION

Gilmartin Receives Department of Commerce Bronze Medal Award

William G. Gilmartin, leader of the endangered Hawaiian monk seal recovery program, received the Department of Commerce Bronze Medal award for his leadership in developing and implementing the Hawaiian Monk Seal Head Start and Rehabilitation Projects at Kure Atoll. The principal goal of research efforts led by Gilmartin has been to promote population recovery of the monk seal in the Northwestern Hawaiian Islands. Because of these efforts, the number of seals and births at Kure are both increasing and, as more of the females from the recovery project mature, the number of births should continue to rise, hopefully securing the future of the Kure population.

The Bronze Medal award represents the agency's recognition of Gilmartin's work. He and his staff have applied their scientific expertise to solve a problem in one of the agency's key missions—that of protection and recovery of a critically endangered marine mammal.

Preliminary Results of 1992 Northwestern Hawaiian Islands Hawaiian Monk Seal Field Season Given

Field camps were again established this year at all five major breeding sites of the Hawaiian monk

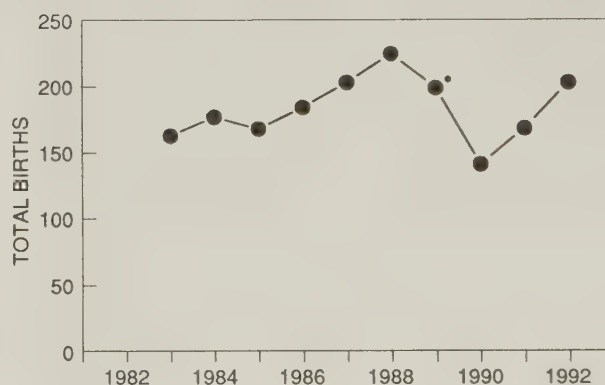


Figure 1. Minimum number of Hawaiian monk seal births in the Northwestern Hawaiian Islands, 1983-92. (*No visits made to Lisianski Island in 1989. Average number of births for 1983-1992 added to that year's total.)

seal, *Monachus schauinslandi*. Staff were also present intermittently at Midway Islands. Population monitoring, including weaned pup tagging and tag resighting for survival data, and marine debris inventory and destruction were conducted at all sites. One primary concern was the status of the French Frigate Shoals (FFS) population and whether the declines in births and beach counts observed during 1990-91 continued into 1992. Preliminary 1992 figures for total births compared to earlier years is presented in Figure 1. Brief highlights of the activities and findings at each breeding site are provided below.

Kure Atoll

Field activities were conducted on Kure Atoll from March 8 to July 17 by Jim Swensen. Thirteen pups survived to weaning and were tagged, and 12 of these were resighted within 1 week of the end of the field camp. The mean seal beach count increased one seal over the 1991 mean count. Two injured seals were observed during the field season. One seal was found entangled in debris, which was subsequently removed. No deaths, other than a neonatal pup, were recorded. The female pup Head Start project was not conducted at Kure in 1992, nor were rehabilitated yearling females introduced to the population. On July 2, the Coast Guard loran station on Green Island was officially decommissioned. On July 10, to ensure that no seals would be injured, seals were chased off island beaches in the vicinity of the 625-ft loran signal transmission tower prior to its demolition. NMFS staff and all Coast Guard personnel were removed from the island by July 31.

Midway Islands

Field activities at Midway Islands commenced in late April when John Henderson and two volunteers constructed an enclosure on Sand Island to temporarily maintain seals relocated to Midway from other islands. As a result of this and several other seal shipments, 20 female seals have been moved to Midway, where they have been fed and cared for by various staff members. Six of the relocated seals were yearlings collected in 1991 from other islands as underdeveloped pups and rehabilitated at Sea Life Park on Oahu. The remaining 14 seals (3 weaned pups, 7 yearlings, 2 two year olds, and 2 three year olds) were collected in 1992 from FFS. Five of the 14 were temporarily maintained on Oahu, and 9 were transferred directly to Midway. A single pup was born at Midway in 1992. One adult female was seen with a back injury likely

sustained in a mobbing incident. No deaths or entanglements were documented.

Pearl and Hermes Reef

Field observations were conducted on Pearl and Hermes Reef during July 20-25 under the supervision of LTJG Michele Finn, with the base support of the NOAA Ship *Townsend Cromwell*. During this brief period, five full atoll counts were accomplished; the mean count was higher than for recent years. Twenty-six births were documented, the highest recorded at this site. Twenty-three pups were tagged. One male pup was found entangled in a fishing net and was released unharmed. An adult female was observed to have sustained a fresh shark wound to the head above the right eye, possibly sustaining damage to the eye. The skeleton of a male yearling was found, but no other deaths or injuries were noted.

Lisianski Island

Fieldwork was conducted at Lisianski Island during March 21-July 17 under the supervision of Lisa Hiruki. The 23 births observed were much higher than those reported in 1990 and 1991. Twenty-one weaned pups and five immature seals were tagged. The 1992 population was fully identified as to age and sex composition. Two juvenile (2-year-old) seals died, a female died from mobbing injuries inflicted by adult male seals, and a male died from unknown causes. Six females (five adults, one subadult) sustained gaping dorsal injuries from adult male seals. Five seals were injured by large sharks. Ten entanglements of various island species were observed: eight seals (seven released by field party, one freed itself), one turtle (not freed), and one albatross chick (released by field party).

Laysan Island

A field camp was in place at Laysan Island during March 20-July 26 under the leadership of Brenda Becker, wildlife biologist. The composition of the population was little changed from 1991. Births, at 37, were the second highest recorded since 1983. Thirty-four of the pups survived to weaning, and all but two were tagged. Thirty-two weaned pups, 23 1-year-olds, and 10 2-year-olds were weighed and measured as part of the immature seal growth study. Eleven mortalities were documented at Laysan Island, seven of which were attributed to mobbing. No mobbing incidents were observed, but 10 seals with mobbing injuries, resulting in the deaths described above, were seen. One entangle-

ment of a seal by a plastic strap was observed, and the strapping was removed from the animal. A pilot study was also conducted to test field use of a drug to reduce testosterone in adult males to control mobbing activity. Nineteen males (10 experimental, 9 control) were instrumented with a very high frequency (VHF) transmitter and time-depth recorder packages to test the effects of the drug on seal activity patterns. Ten additional males were used as a control for handling. The effects of the drug in altering testosterone levels, haul-out association patterns, and diving patterns are currently being analyzed.

French Frigate Shoals

Field activities were conducted at French Frigate Shoals (FFS) during March 25–October 7. The mean non-pup beach count of 174 shows evidence for a continuing decline in this population. An encouraging sign, however, was an increase in births to 102, up from 82 last year. Of the pups born, 86 survived to weaning as of September 17; 6 were still nursing. Seven undersized, weaned female pups were collected and transported to Sea Life Park for rehabilitation. Six juveniles were found dead, 4 of which were emaciated. Weight, length, and girth data were collected on a total of 42 juveniles and 72 weaned pups. Two abandoned pups were successfully reunited with their mothers. A piece of fishing net around a subadult female's neck and a loop of line around a pregnant female's chest were removed. Finally, as part of a study to determine monk seal foraging patterns, three subadult males were equipped with satellite-linked time-depth recorders. (W. Gilmartin, [808] 943-1239)

Investigation Initiated in Response to High Juvenile Mortality at FFS

Following receipt of the early 1992 census data from the French Frigate Shoals (FFS) camp indicating a further decline in beach counts since the previous summer, a disease investigation was initiated. Animal samplings were conducted in April and included physical examinations, blood cell counts, serum chemistry profiles, heartworm microfilaria and gastrointestinal parasite examinations, *Salmonella* and viral cultures, and antibody screening for evidence of canine distemper, toxoplasmosis, parvovirus, leptospirosis, and marine mammal caliciviruses. Endemic parasites and *Salmonella* were determined to be present in the animals. However, findings did not suggest that a disease was responsible for the observed high incidence of emaciation and death. In May, an experi-

mental immature seal collection/rehabilitation/relocation project was initiated. Seven seals, classified as thin to emaciated, were collected and transported to Oahu, where they were examined, treated, and fed. Five of these seals survived, and following disease screening in August, they were transported to Midway where they were released. In September, another collection/rehabilitation was conducted at FFS, with nine immature females being moved directly to Midway after disease screening. In subsequent years, survival of the rehabilitated and relocated females will be compared with their male counterparts remaining at FFS to evaluate the benefit of this undertaking. (W. Gilmartin, [808] 943-1239)

INSULAR RESOURCES INVESTIGATION

Populations of the mysid, *Gnathophausia longispina*, at Southeast Hancock Seamount Studied

Research conducted concurrently with the stock assessment of pelagic armorhead at Southeast Hancock Seamount, located at the northwestern end of the Hawaiian chain, included work on the unique micronekton populations above that seamount. Oceanographer Christopher Wilson (presently at the Alaska Fisheries Science Center) and Fishery Biologist George Boehlert characterized the populations of the lophogastrid mysid, *Gnathophausia longispina*, an abundant species at these seamounts that was previously considered to be relatively rare (occurring singly at several locations around the Pacific). The species was first caught in 1984 over Southeast (SE) Hancock Seamount during midwater trawls through dense sound-scattering layers above the seamount. Further collections at SE Hancock were made on cruises on the ship *Townsend Cromwell* through 1988 and were used to describe the life history of this little-known species. The mysids remain near the seamount substrate during the daytime, moving into the water column at night, generally within 100 m above the 265 m deep summit.

Growth was measured by modal progression of size classes over time. At SE Hancock Seamount, it appears that *G. longispina* reach sexual maturity by their second year. Females brood the young for at least 7 months before releasing them during late winter/early spring; development of embryos is nearly synchronous among the brooding females. It is doubtful that females produce more than a single brood during their lifetimes. Because no

other large populations of *G. longispina* are reported from other seamounts along the southern Emperor-northern Hawaiian ridge region, it is suggested that this species is maintained by local recruitment rather than immigration. (G. Boehlert, [808] 943-1211)

Jeffrey Polovina Completes Fulbright Fellowship

Jeffrey Polovina, chief of Insular Resources Investigations, returned in September from a 3-month Fulbright Research Scholar Program in Kenya where he worked on three research projects.

The first project initiated involved working with two Kenyan biologists to build and deploy artificial shelters (casitas) and monitor their effectiveness in the artisanal lobster fishery. Two different types of shelters similar to the ones used in the Gulf of Mexico were built and deployed in Kenyan coastal waters. Fishermen have reported catches averaging 1.5 kg of lobster per visit from the shelters, and the Kenyan biologists are continuing to monitor the catches. Further, since little has been written on the Kenyan lobster fishery, a description of the Kenyan spiny lobster fishery was written and will be included in an international book on spiny lobster fisheries and ecology.

After the lobster shelters were deployed and were being monitored, Polovina traveled to Lake Victoria to work with a statistician who had 3 years of detailed catch-and-effort data, categorized according to gear used, for 22 landing sites from the Kenyan portion of Lake Victoria. They analyzed the data, used the results to develop a computer simulation model to describe the dynamics of the Nile Perch population and fishery, and presented the results at a workshop in Uganda.

The last project involved working with a Kenyan biologist in Mombasa to use a time series on rainfall from coastal stations since 1963 to document wet and dry decadal climatic periods and then to evaluate whether there have been changes in the coastal marine ecosystem between the climatic periods. Substantial differences in coastal rainfall on a decadal scale were documented, but it was concluded that the existing biological or fishery data were insufficient to evaluate whether there were corresponding differences in the marine ecosystem. This work will be presented at a large marine ecosystem meeting in Mombasa in March 1993. (J. Polovina, [808] 943-1218)

Preliminary Trap Surveys of Juvenile Opakapaka

Honolulu Laboratory fisheries biologists continued preliminary trapping surveys of the opakapaka or Hawaiian pink snapper, *Pristipomoides filamentosus* (family Lutjanidae). A primary objective has been to develop trap and sampling designs that can be used to index juvenile snapper abundance and distribution with both accuracy and precision, but without undue impacts on the fish themselves or habitat.

During the August 5-24, 1992, cruise (TC-92-07) of the NOAA ship *Townsend Cromwell*, multiple strings of baited funnel traps were deployed at Necker Island and French Frigate Shoals (FFS) in the Northwest Hawaiian Islands (NWHI) and off Kaneohe Bay, windward Oahu; and Kolo Harbor, southwest Molokai; in the main Hawaiian Islands (MHI). Traps were fished in primary juvenile habitat--on unconsolidated bottoms at 73-91 m (40-50 fathoms [fm])--or the closest depths available--based on the findings of prior hook-and-line and bottom trawl surveys.

Rectangular traps of different sizes and construction materials were evaluated. The two trap sizes tested were large (1.8 m long x 1.2 m wide [6 ft long x 4 ft wide] x 0.9 m [3 ft] high) and small (1.2 m long x 0.9 m wide [4 ft long x 3 ft wide] x 0.61 m [2 ft] high). Traps were constructed either of 1-cm (0.5-in) hardware cloth or 2.5-cm (1-in) chicken wire; some traps of both sizes and types of materials were lined with nylon "skirts" of 0.3-cm (0.125-in) nylon netting and other traps were not. Each trap had a single, relatively narrow funnel (8-cm [3-in] maximum width, to prevent possible entrapment of monk seals) at one of its two long ends and was baited with 5 kg of chopped mackerel, *Scomber japonicus*, held in several hardware cloth baiters anchored near its funnel end. Traps were fished for 3.5-4 days (3-night soak) in 5-trap strings, with individual traps spaced 55 m (30 fm) apart.

Traps of both sizes and construction types caught juvenile opakapaka. Traps with fine nylon-mesh liners inflicted less mechanical damage to fish during the retrieval and emptying of traps aboard ship, an important consideration if live specimens are needed for subsequent studies (e.g., grow-out experiments). Other results available at present are limited to catch lists, by species, and summary statistics for juvenile opakapaka at each of the four sampling sites. Total catches are listed for the two MHI sites that yielded the largest number of opakapaka (Table 1). Subsequent analyses of these and

Table 1. List of fishes trapped off Kaneohe Bay, windward Oahu; and off Kolo Harbor, southwest Molokai; in the Main Hawaiian Islands, on *Townsend Cromwell* cruise TC-92-07 (August 5-24, 1992). Taxa are listed by decreasing catch numbers (N); weights (Wt, kg) are also provided.

Taxa	Kaneohe Bay Oahu		Taxa	Kolo Harbor Molokai	
	N	Wt		N	Wt
<i>Pristipomoides filamentosus</i>	383	59.6	<i>Lutjanus kasmira</i>	190	36.4
<i>Priacanthus alalana</i>	91	3.2	<i>Heniochus diphreutes</i>	92	7.4
<i>Lutjanus kasmira</i>	65	4.2	<i>Pristipomoides filamentosus</i>	89	23.8
<i>Parupeneus chrysonemus</i>	31	1.9	<i>Seriola dumerili</i>	33	25.1
7 others	39	1.5	19 others	55	7.0
Total fishes	609	70.4	Total fishes	459	99.7

additional trap catch data will be used to evaluate the precision of juvenile opakapaka catch-per-unit effort (CPUE) among traps and within strings of traps; these precision estimates will be used to help specify levels of sampling effort in future trap surveys of juvenile snapper abundance.

Catches at the two NWHI sites and at the two MHI sites (Table 1) varied in composition and magnitude. Shallower 22-m to 37-m (12-fm to 20-fm) depths and more heterogeneous substrates obviously influenced catches at the Necker Island site, where scientists used remote video drops to detect the presence of live coral heads interspersed with sand. Four strings (18/20 baited traps) at Necker Island caught 31 taxa of fishes totaling 1,573 individuals weighing 425 kg. Taape or blue-lined snapper, *Lutjanus kasmira*, an exotic species that was first introduced to the MHI in 1958, comprised 79 percent by numbers and 76 percent by weight of the total catch. No juvenile opakapaka were trapped.

Two strings (10 traps) were deployed at 80-87 m (44-48 fm) on expansive sand substrate off northwest FFS. The aggregate catch was 123 individuals of 12 taxa weighing 25 kg, including three juvenile opakapaka (15.1-16.6 cm fork length [FL]). These represent the first reported catches of young-of-the-year (YOY)-sized opakapaka from anywhere in the NWHI.

Off Kaneohe Bay, windward Oahu; four strings of traps (20 traps) were fished on sandy mud bottoms at 82-91 m (45-50 fm). The total catch was 609 individuals of 11 taxa weighing 70 kg (Table 1). YOY and one-year-and-older juvenile (13.2-28.8 cm FL) opakapaka comprised 63 percent and 85 percent

of all fishes by number and weight, respectively. Haole crab, *Portunus sanguinolentus*, of local commercial importance, accounted for another 8+ kg catch.

Four strings of traps (20 traps) were fished at 91 m (50 fm) on sand and hard pan bottoms off Kolo Harbor, southwest Molokai; 459 individuals of 23 taxa weighing 100 kg were caught (Table 1). Juvenile opakapaka comprised 19 percent (number) and 24 percent (weight) of all fishes trapped; the lengths of these YOY-to-large juveniles spanned 13.6-35.3 cm FL. Haole crab contributed another 7 kg. (E. DeMartini, [808] 943-1266)

FISHERY MANAGEMENT AND PERFORMANCE INVESTIGATION

Data Collection and Compilation Procedures Reviewed

Joseph E. Powers, Acting Deputy Director of the Southeast Fisheries Science Center, conducted a review of the data collection and compilation procedures of the Honolulu Laboratory this past summer. Powers conducted a site visit June 12-July 2, 1992, and subsequently issued a report which is summarized here.

The overall objective of the review was to assess the procedures of Fishery Management Plan (FMP)-related fisheries data collection and compilation in Hawaii, Guam, American Samoa, and the Commonwealth of the Northern Marianas through the Western Pacific Fisheries Information Network (WPACFIN) and the Fishery Monitoring and Performance Investigation of the Honolulu Laboratory. Specifically, the objectives were to: (1)

evaluate the adequacy of existing procedures and currently defined priorities regarding fisheries data; and (2) advise on the sufficiency of data being collected for the fishery management and stock assessment objectives as defined in the Pelagics, Bottomfish and Seamount Groundfish, and Crustacean FMPs.

Personnel of the Honolulu Laboratory, the Southwest Regional Office (SWRO), and the Western Pacific Fishery Management Council (WPFMC) were consulted and interviewed in depth. Additionally, Powers attended Council, WPFMC Scientific and Statistical Committee, and WPACFIN Fisheries Data Coordinating Committee meetings to afford himself the opportunity to further understand the data perspective of the State, Commonwealth, and Territories, in addition to that of the Council and SWRO. Finally, a large number of documents prepared by the Honolulu Laboratory and cooperators on the status of fishery resources of the area, project designs, data collection program proposals, the status of research projects, and on the results of collection surveys and programs were examined to provide the appropriate framework for the review.

After the review, Powers made three principal recommendations:

- (1) A high priority should be given to developing integrated data bases for use of analyses by the Honolulu Laboratory and to provide scientific support to the Council.
- (2) The primary fisheries-dependent data needed for fisheries management include total catch, catch by size/sex/user-group and detailed effort data. While much of this is being collected presently, collection activities need to be improved in the pelagics and bottomfish fisheries of the main Hawaiian Islands.
- (3) The Honolulu Laboratory should be prepared to conduct stock-wide assessments for pelagics (particularly swordfish) using data from all national fleets within 3-5 years.

On data collection, Powers concluded that inadequate information was available as to main Hawaiian Islands bottomfish and pelagics catch, landings, and fishing effort. An appropriate data collection system would be one in which (1) logbooks with daily entries are required for commercial vessel trips, (2) processors (point of first sale) are required to report their transactions (provides economic information, as well as verification of logbooks, (3) a State and/or Federal staff sample is made at the

dock for size/sex and to facilitate verification of logbooks and processor reports, (4) a recreational survey is implemented to estimate non-commercial catch and effort, and (5) observers are appropriately placed on selected trips to determine non-landed catches and other effort characteristics.

Powers suggested that with pelagic fisheries expanding and momentum building to deal with bottomfish problems in Hawaii, it is extremely important that the data base organization take priority. Without this, the Laboratory's responses will be ad hoc and half a step behind. Powers' conclusions have been discussed with the Honolulu Laboratory and presented to the WPFMC. Implementation of most of the recommendations is proceeding as funding allows. (S. Pooley, [808] 943-1216)

PELAGIC FISHERIES RESOURCES DIVISION

La Jolla, California

MULTISPECIES DATA COLLECTION AND EVALUATION PROGRAM

Seychelles Purse-Seine Data Updated

Biological Technician Gary Rensink has completed updating the first quarter 1992 Seychelles Fishing Authority data from tuna purse seiners fishing in the western Indian Ocean. Data are summarized in LOTUS spreadsheets and cover the period 1983 to the present.

The number of vessels participating in the purse-seine fishery in the western Indian Ocean during the first quarter of 1992 averaged 53 (17 French, 17 Spanish, 3 Mauritian, 1 Panamanian, 3 Russian, 9 Japanese, 1 Iranian, and 2 Seychelles), a significant increase when compared to the average of 41 vessels recorded for the same period the previous year. This is largely due to the increased allotment of licenses to Japan and a new fishing agreement with Iran.

The first quarter catch rates in 1992 averaged 14 metric tons (t)/day, significantly lower than the 22 t/day recorded for the same period in 1991 (Fig. 1). Catch rates for the first quarter of 1992 were down 65 percent for yellowfin (6 t/day) and up 40 percent for skipjack (7 t/day) from those of the same period in 1991.

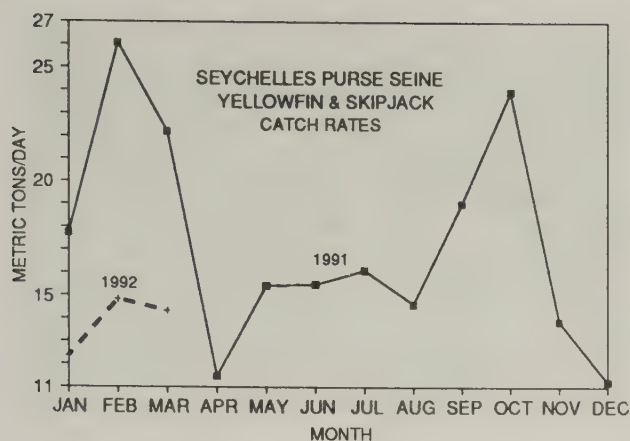


Figure 1. Catch rates (metric tons/day fished) for purse seiners fishing in the western Indian Ocean, 1991-92.

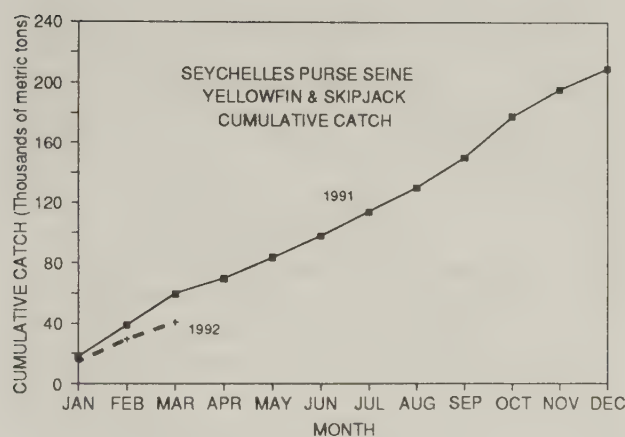


Figure 2. Cumulative catches (metric tons) of yellowfin and skipjack tuna by purse seiners in the western Indian Ocean, 1991-92.

The January-March 1992 yellowfin and skipjack tuna catch in the western Indian Ocean totaled 40,834 t, 32 percent lower than for the same period in 1991 (Fig. 2), due primarily to the lower catch rates and the large number of trips for which log-books had not yet been collected.

The breakdown of tuna catch for the first quarter of 1992 was 47 percent yellowfin, 52 percent skipjack, and 1 percent other tuna, compared to 78 percent yellowfin, 21 percent skipjack, and 1 percent other tuna during the same period in 1991. This change was due to the increased tendency for the Seychelles fleet to concentrate fishing efforts around floating aggregation devices and because of the effects of a strong El Niño-like condition in the Indian Ocean. (G. Rensink, [619] 546-7192)

Dolphin Mortality in U.S. Tuna Fishery Continues to Decline in 1991 and 1992

The estimated number of dolphins killed in the U.S. eastern tropical Pacific tuna purse-seine fishery in 1991 was 1,004, down 80 percent from the estimated 1990 kill of 5,083, according to data collected by on-board observers from the National Marine Fisheries Service. The 1991 dolphin kill was well below the annual quota of 20,500 and was the lowest on record for the U.S. fleet.

The major reasons for the marked decrease in dolphin kill in 1991 were the continued reduction in the size of the U.S. fleet in the eastern Pacific, reduced fishing on dolphin-associated schools, and improved performance. The first two are consequences of the U.S. tuna canners' decision in April 1990 to purchase only dolphin-safe tuna.

In 1990 there were 28 U.S. purse seiners active in the eastern tropical Pacific, of which 26 made sets on dolphins. In 1991 the active fleet declined to 13 vessels, of which only 9 made sets on dolphins. In both years, 1990 and 1991, the observer coverage rates were virtually 100 percent. Ninety-two fishing trips and 1,845 dolphin sets were observed in 1990. In 1991, 47 trips and 430 dolphin sets were observed. The dolphin kill-per-set rate in 1991 was 2.3, down 18 percent from the 1990 rate of 2.8. It was the lowest annual rate ever achieved by the U.S. fleet (Fig. 3).

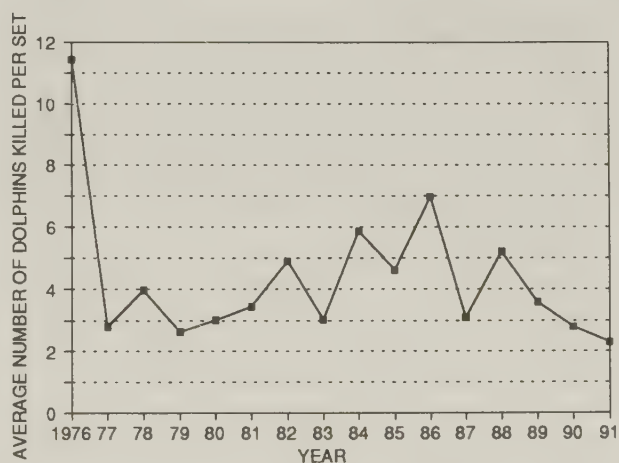


Figure 3. Average number of dolphins killed per set on dolphins for observed U.S. trips, 1976-1991.

Based on preliminary data covering the first eight months of 1992, the dolphin kill and kill-per-set rates continue to fall: 281 dolphins killed in 432 sets for a kill-per-set rate of 0.7. Of the seven U.S.

purse seiners that were active in the eastern tropical Pacific and permitted to set on dolphins, only five actually made dolphin sets during this period. (A. Jackson, [619] 546-7048)

STOCK ASSESSMENT AND FISHERY IMPACT ANALYSIS PROGRAM

Bartoo Receives Department of Commerce Bronze Medal Award

Norman Bartoo, leader of the Stock Assessment and Fishery Impact Analysis Program, received the Department of Commerce Bronze Medal award for his significant role in organizing and directing research on North Pacific albacore during the high-seas driftnet crisis. Over the past decade, Bartoo has conducted highly effective studies designed to monitor the abundance of albacore and measure the impact of high-seas driftnet fishing on the U.S. fishery, which has declined to historically low levels, and he has been instrumental in organizing U.S. albacore fishermen, scientists from the major fishing countries, and U.S. albacore interest groups to help determine and assess the abundance of albacore.

The Bronze Medal award represents the agency's recognition of Bartoo's efforts toward establishing international cooperation in dealing with the albacore fishery.

Marlin Tracked in La Paz, Mexico

Fishery Biologist Dave Holts traveled to La Paz, Mexico, in September to continue acoustic tracking experiments on striped marlin. The experiments began last February in Cabo San Lucas. The behavior patterns of striped marlin vary in different areas of their range as evidenced by previous studies off California and Hawaii. These differing patterns influence their availability to both recreational and commercial fisheries. Holts and Arturo Muhlia of Centro de Investigaciones Biologicas (CIB), La Paz, as principal investigators, were joined by various researchers from Centro Interdisciplinario de Ciencias Marinas (CICIMAR), La Paz, in this recent effort to track the daily activity patterns of striped marlin in the waters off Baja California, Sur. CIB's 9-m work boat *Barko CIB* (Fig. 4) was converted into a tracking vessel with hydrophones, acoustic receivers, data recorders, GPS navigation system, XBT thermal recording equipment, and a modest amount of sport fishing gear by which to capture marlin. The first three days were spent fishing for striped marlin with no success except for a few dorado and sailfish not suitable for tracking.



Figure 4. U.S./Mexican marlin tracking off La Paz, Mexico, in September 1992 aboard the Centro de Investigaciones Biologicas' vessel *Barko CIB*.

On the fourth day of fishing, an 80-kg striped marlin was caught, tagged, and released. The scientists monitored the activity of this marlin for approximately 20 nm, near the northwest end of Isla Cerralvo, during the next 24 hours (Fig. 5). When released, it descended to 20 m - 30 m for several hours while moving very slowly away from the Isla Cerralvo. As darkness approached, the marlin moved northeast and remained near the surface in the area just west of the north end of Cerralvo. In the morning it became more active vertically and circled around to the north for another 8-to-10 nm. Its maximum depth was to 47 m at 8:00 p.m. but

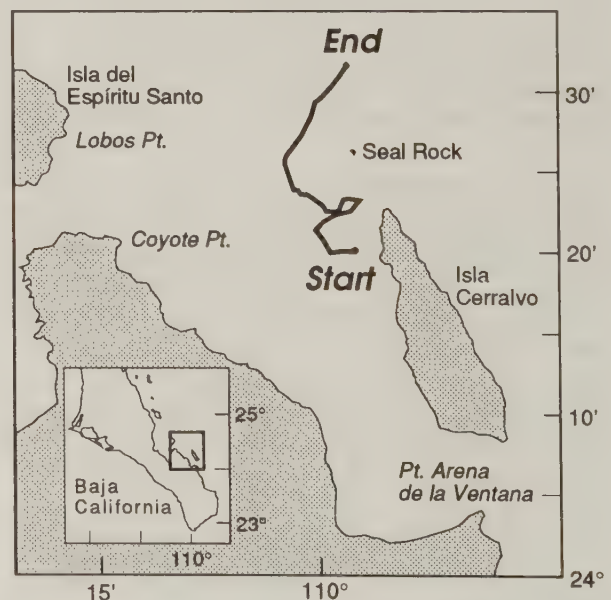


Figure 5. Path of a striped marlin tracked from near the northwest end of Isla Cerralvo north for approximately 20 nm.

usually descended no deeper than 30 to 35 m. The thermocline in this area was also 30 to 35 m deep but the temperature only decreased from about 30.5° C at the surface to 29.5° C at 35 m and 24° C at 50 m. Rate of movement was approximately 1 kt. This fish was tracked for 24 hours before the scientists were required to return to La Paz.

This tracking complements the experiment conducted off Cabo San Lucas last February. In both experiments, striped marlin for the most part stayed above the thermocline as they moved in a general direction away from land and into the open ocean environment.

Both investigators felt the experiment was a success in that several associate researchers gained experience in the tracking technique and data collection procedures. Problems with the vessel's equipment and tracking equipment encountered in February were easily resolved this time and many new techniques were refined, including fish-handling methods and procedures for attaching transmitters to large, active fish. (D. Holts, [619] 546-7186)

Other Large Pelagics Tagged

Laura Halko, biological technician, and Dave Holts, fishery biologist, of the Southwest Fisheries Science Center in La Jolla participated in a 3-day tagging cruise aboard the research vessel *Point Sur* during the first week of September, offshore San Francisco, south of the Farallon Islands. The cruise was conducted by the Monterey Bay Aquarium Research Institute (MBARI), using newly acquired longline gear, to capture selected pelagic fish for aquatic exhibits. One goal of the cruise was the sharing of ideas concerning the configuration and deployment of the gear including the retrieval of healthy specimens. The second goal was to tag and release the expected by-catch of swordfish and a variety of sharks if retrieved alive and to do biological work-ups if dead.

Two longline sets were conducted. The first set was impaired when several floats malfunctioned allowing the longline to sink well below the desired fishing depth. These floats were replaced with bumper buoys for the second set and the longline fishery gear worked as planned. In all, 12 blue sharks were tagged and released and 6 others were measured and weighed. One grenadier and one "king of the salmon" were collected by MBARI. Additionally, six mid-water and two shallow-water trawls were conducted by aquarium staff. These yielded copious amounts of both vertebrates and

invertebrates for their ongoing research as well as for display. (D. Holts, [619] 546-7186)

Albacore Observers Complete 1992 Trips

Observers placed aboard cooperating U.S. albacore trollers by the Pelagic Fisheries Research Division and assisted by the Honolulu Laboratory completed 3 trips totaling 228 sea days during the 1992 fishing season. The observers were part of a cooperative industry-NMFS project begun in 1990 to quantify fishery interactions between the high seas, large-scale drift-gillnet fishery and the U.S. troll fishery in the Pacific Ocean. Each season since 1990, observers have quantified numbers of albacore caught in the U.S. fishery which bear marks or scars from encounters with the gillnet fishery. In 1992, observers examined in excess of 15,000 albacore for evidence of encounters with gillnets. As in previous years, net marks were most evident on fish captured west of 140° W, in and toward the area of gillnet fishing, and these fish average nearly 8.5 percent of the catch. East of 140° W, toward the U.S. coast, the proportion of marked fish declined to 2.4 percent. The overall incidence of marked fish in 1992 was 4.6 percent of the sample as compared to 3.1 percent seen in 1991 and 12.4 percent in 1990.

Under a United Nations-sponsored resolution; high seas, large-scale drift gillnetting is to terminate at the end of 1992. Scientists expect the presence of net-marked fish to decline markedly in 1993, reaching near zero in 1994 or 1995 as previously injured fish grow and become unavailable to the U.S. fishery. (N. Bartoo, [619] 546-7073)

Pelagic Ecosystem Model Development Program

Computer Simulations of Fish Populations

One of the important activities of the Pelagic Ecosystem Model Development Program is to develop computer simulations of fish populations based on mathematical models that can include mortality, drift velocity, and diffusivity. The problem is that the more realistic the model becomes, the harder it is to simulate it. Operations Research Analyst Carlos A. M. Salvadó, however, has developed a numerical technique that simplifies simulations of populations in complex environments.

The approach taken by Salvadó employs the method of Green functions, which has been reported in previous issues of the Bimonthly Report of Activities. In a further development using this method, Salvadó has developed a technique that

allows the simulation of realistic models of the dynamics of populations that move, including the presence of complex geographic boundaries. In addition, he has derived an expression in closed form for the transition probability densities of the exchange of fish between the discrete zones of the population domain. Simulations are therefore considerably simplified. (C. Salvadó, [619] 546-7052)

TIBURON LABORATORY

Tiburon, California

GROUNDFISH ANALYSIS INVESTIGATION

Study Conducted of Cobb Seamount Fishery

The Cobb Seamount is located approximately 300 miles due west of the Oregon-Washington border. It rises from the bottom to a depth of about 60 meters. Since its discovery in 1950, domestic and foreign commercial vessels have periodically visited the seamount. In addition, some research has been conducted on and around the seamount. Recently, a Taylor column has been proven to exist on the seamount, and it has been found that primary productivity is quite high compared to the surrounding waters. In September of 1991, U.S. commercial fishing vessels returned to the Cobb Seamount and began making large landings of widow rockfish, *Sebastes entomelas*.

These landings were of particular concern to the Pacific Fishery Management Council because, while the fish were caught outside the Exclusive Economic Zone, they were being landed in Oregon and Washington where trip limits for widow rockfish are in place. All the landings exceeded the trip limits and, to date, more than 800 tons of widow rockfish have been landed in Oregon and Washington ports. In addition to the management issues raised by this fishing activity, there has been a great deal of interest in the biological characteristics of the fish being landed from this geographically isolated population.

Researchers from the Oregon Department of Fish and Wildlife, in conjunction with personnel from the Southwest Fisheries Science Center at Tiburon, began an examination of the Cobb Seamount fishery. Port samplers in Oregon were requested to give high priority to sampling fish from the Cobb

Seamount and to take larger-than-normal samples. Species composition, maturity, length, and age composition of the fish have been examined, and the results are interesting.

Since attainment of sexual maturity is linked to growth rate and age for widow rockfish as in other animals, it should follow that if growth rate and length-at-age are the same for two populations, then the age of maturity and length-at-maturity should be similar. However, this examination indicates otherwise. For instance, widow rockfish on the Cobb Seamount have a similar length-at-age as the widow rockfish landed on the coast, but widow rockfish mature at an earlier age on the Cobb Seamount than they do on the coast. Also, for widow rockfish landed on the Cobb Seamount, 99 percent are from 1985 and later year classes. Less than 50 percent of widow rockfish landing in the coastal fishery are from 1985 and later year classes. Additionally, there is evidence that weak cohorts on the coast are strong cohorts on the seamount, and possibly vice versa. Interestingly, a 50-fish sample of harlequin rockfish, *S. variegatus*, from the seamount was much older than the widows, with a mean age of 15 years.

One of the biggest surprises encountered by the researchers was the fact that a phenomenon known as "resorption," in which otoliths appear to be crystallized, occurs in 27 percent of the fish from the seamount, while less than 3 percent of the fish on the coast exhibit this phenomenon. Little is known about the causes of resorption or its biological significance.

Other discoveries regarding record length fish, range extensions, and unusual morphologies in several different species have been observed. Research is continuing, and it is hoped that additional samples of other species, including sablefish, will provide additional clues into the fishery and biological characteristics of this unique area. Results of this investigation are being prepared for publication as a note in *Fishery Bulletin*. (D. Pearson, [415] 435-3149)

GROUNDFISH COMMUNITIES INVESTIGATION

Estimates of Recreational Lingcod Catch May Need to be Adjusted

Estimates of the recreational catch for lingcod used in the Pacific Fishery Management Council stock assessment document are based on data from the Marine Recreational Fisheries Statistics Survey

(MRFSS), which covers the catch in California, Oregon, and Washington from 1981 to 1989. This survey, a combination of telephone and direct-contact interviews with anglers, has been a major source of data for Fishery Biologists Pete Adams and Kelly Silberberg in their assessment of the lingcod stock. The reliability of this survey has recently been questioned, however, by scientists comparing it to another set of estimates for the same years in the state of Washington. These are results of the Washington Ocean Sport Fishery Survey provided by T. Jagielo of the Washington Department of Fisheries. The Washington survey, which combined a count of the number of boats putting to sea with direct-contact interviews with anglers, produced results very different from those of the MRFSS survey.

The MRFSS estimates have ranged from 1.27 to 18.00 times higher than those of the Washington survey, with the greatest differences occurring during the first few years (1981-1983) and the least difference during 1989, the most recent year (Fig. 1). The Washington survey must be considered the more reliable for two reasons. First, it has been established that anglers interviewed by telephone tend to overstate both the number of their trips and the size of their catch. And, second, the Washington survey involved far more intensive sampling. As many as 50 percent of the estimates in the Washington survey resulted from direct-contact interviews with anglers, compared to 0.2 to 0.8 percent of the MRFSS estimates.

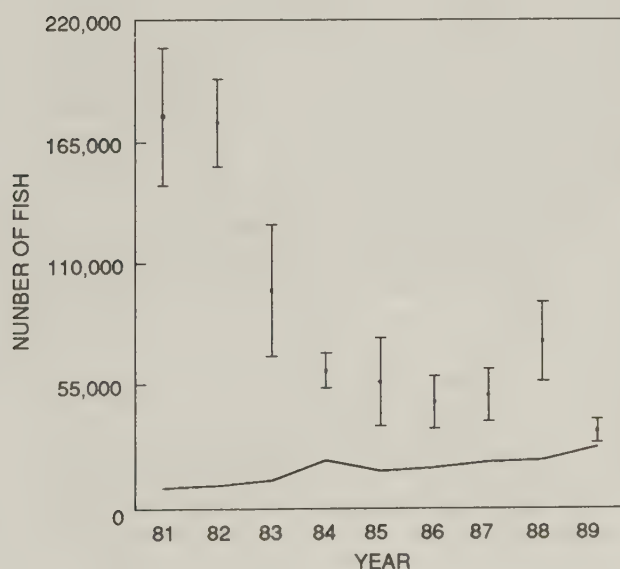


Figure 1. Comparison of Washington State Ocean Sport Fishing lingcod recreational catch estimates (solid line) and MRFSS estimates (data points with error bars) from 1981 to 1989.

The doubt cast on the MRFSS estimates limits their usefulness, and any conclusions based on these estimates must be tempered by the possibility that they may be seriously overstated. Before future MRFSS surveys are undertaken, there should be a critical evaluation of telephone interviews, and provisions should be made for increasing the proportion of interviews that involve direct contact with the anglers. (P. Adams and K. Silberberg, [415] 435-3149)

GROUND FISH PHYSIOLOGICAL ECOLOGY INVESTIGATION

Researchers Study Metabolic Costs Involved in Yellowtail Rockfish Livebearing

During laboratory experiments to monitor embryonic and larval development inside pregnant yellowtail rockfish, scientists observed that captive reproductive fish displayed decreased activity, voluntary fasting, and hyperventilation. This behavior became accentuated as the time of parturition approached, implying that embryos and larvae increased their demands on the host mother as they developed. With the partial support of Sea Grant, a series of experiments was conducted by Maxwell Eldridge, fishery biologist, of the Tiburon Laboratory and Joe Cech and his graduate student, Tod Hopkins, from the University of California, Davis, to accurately determine the change in routine metabolism of host, adult rockfish throughout gestation. Such physiological metabolic information has implications for maternal energy budgets and the ability of gestating fish to withstand stress, such as high water temperatures and low food availability which occurred during recent El Niño conditions.

Adult fish were collected by hook and line from Cordell Bank, California, and transported to 2000-liter circular tanks at the University of California, Bodega Marine Laboratory, where they were acclimated for a minimum of two weeks to aerated seawater, with ambient temperatures (mean temperature = 11.9 °C), salinities (mean = 33.0 ppt), and photoperiods. Fish from the field were classified, after mild anesthesia and catheterization (Fig. 2), into reproductive classes of vitellogenic, early embryo, late embryo, larva, spent, and male. Another stage comparison was also possible by testing sexually mature, non-reproducing females that were maintained in the laboratory for one to two years. These fish were kept apart from males throughout their captivity and were known to be reproductively inactive.

Resting-routine metabolism is the level of oxygen being consumed by a fish while in a non-active

state. Resting-routine metabolism in this study was measured by placing lightly anesthetized fish in four 13-liter, flow-through, plexiglass respirometers.



Figure 2. Catheterization procedure of anesthetized yellowtail rockfish. Sampling of eggs allowed the host female to be assigned a reproductive stage.

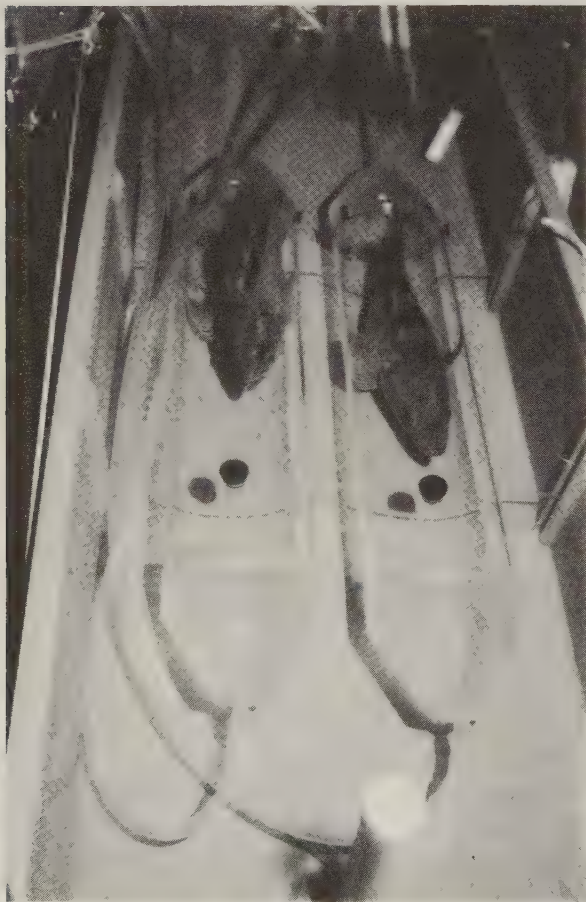


Figure 3. Flow-through respirometers with covers removed to show fish being measured for oxygen consumption.

ters that were immersed in 250-liter, insulated fiberglass tanks maintained at 10 °C with a system of interconnected pumps and siphons (Fig. 3). Oxygen consumption was automatically measured and recorded by shunting water past an oxygen electrode linked to a strip chart recorder. An initial continuous 48-hour experiment was conducted to determine an appropriate acclimation period. Thereafter, experiments were run for 24 hours each with a total of 34 individual fish, representing seven different reproductive stages.

Protocol Revision

Two behavioral and physiological responses were observed in the initial 48-hour experiment that determined the protocol for the subsequent test. First, fish required approximately 12 hours of acclimation before accurate measurements of resting-routine metabolism could be taken. During the first 12 hours, fish oxygen consumption was erratic and unstable. Second, most fish responded to light changes, such as occurred at dawn and dusk, with dramatic increases in respiration rates. Consequently, the researchers decided that the most accurate measures were to be obtained after 12 hours of acclimation and that the "spike" rate values within the measured period would be discounted from the calculation of resting/routine metabolism. These findings imply that adult rockfish require extended acclimation periods for accurate measurements of metabolism and that they can suddenly increase their metabolic rates when disturbed by changes in light conditions.

Metabolism Results

A mass-independent, resting-routine metabolism means that the level of oxygen consumption by the fish, while in a non-active state, is adjusted according to the size of the fish. The mean mass-independent, resting-routine metabolism of the rockfish in this study was found to significantly increase as gestation progressed (Fig. 4). The observed pattern showed that supporting even unfertilized eggs has a cost (i.e., vitellogenic and gestating stages were higher than both spent females and males). As embryonic and larval development proceeded, metabolism significantly increased, especially during late embryo and larval stages, approximately 11-28 days post-fertilization. Comparisons show that females with larvae respired at 63 percent higher levels than spent fish and 86 percent higher than males.

An enigmatic, unexpected result was the dramatically high metabolism of non-reproducing females. The mean oxygen consumption rate of

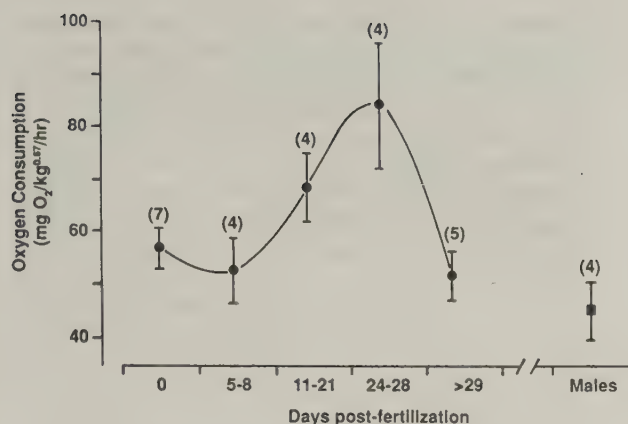


Figure 4. Mean and standard error bars of mass-independent, resting-routine oxygen consumption of yellowtail rockfish. Fish at 0 days post-fertilization were classified as vitellogenic; those at 5-8 days, early embryo; those at 11-21 days, late embryo; those at 24-28 days, larva; those at >29 days, spent. Numbers in parentheses represent replicate measurements within each reproductive class.

four replicate females was 98.034 mg O₂/kg/hr for the weight specific rate and 104.800 units for the mass-independent metabolic rate. These rates were 36.7 percent and 24.4 percent greater than those of the highest metabolizing pregnant females. This suggests that fish held captive for extended periods may be unsuitable for metabolism experiments.

The 1991-92 reproductive season in the coastal waters off northern California experienced the warm water temperatures of an El Niño. Proximate effects of these high temperatures were observed in our laboratory fish toward the end of the study as fish resorbed or aborted their embryos or larvae. The results of our metabolism study demonstrated the potential for reproductive failure when conditions of stress from advanced stage pregnancy and high temperatures are combined. (M. Eldridge, [415] 435-3149)

INFORMATION TECHNOLOGY SERVICES

cc:MAIL Installed on LAN

The new email package, cc:MAIL, was installed on the La Jolla LAN during the week of October 26-30, 1992. The new email package was run concurrently with 3+Mail through

November 6, affording La Jolla's email users an opportunity to learn the new package and test it out before the final cutover to cc:MAIL. As of November 5, cc:MAIL is to be considered the NMFS standard, operational email package.

A cc:MAIL "Quick Reference Card," outlining common email procedures, was photocopied and distributed to La Jolla's email users in order to ease the transition. Interested users may borrow more comprehensive instructional books from Frank Ralston on short-term loan should they so desire.

A cc:MAIL trainer/demo program, not the "live" copy, is available to network users. Some users may find it useful for its "slide show" of cc:MAIL features. It can be easily installed on the user's hard disk over the network by simply typing INSTALL at the G:\CCMAIL prompt (see Frank Ralston if you need help with this).

cc:MAIL is literally crammed with advanced email features. Users now have access to a 1400-username data base to ensure addressing of the cc:MAIL is correct. These usernames include all cc:MAIL users at Headquarters, Long Beach, Honolulu, and elsewhere. A cc:MAIL Post Office has been set up at the PFEG in Monterey and cc:MAIL remote service has been installed at the Tiburon Lab improving NMFS email exchanges in the Southwest.

A cc:MAIL gateway to Banyan email has been set up in Silver Springs which allows for the direct exchange of emails with staff at WASC in Seattle and at Pacific Marine Center. This new linkage to the 6000 plus email users on the NOAA Banyan networks greatly extends the "reach" of email from La Jolla.

Once the best linkages between the many cc:MAIL sites have been determined and implemented, more attention will be given to improving the user interface. For instance, LAN user accounts can be set up so the email username and password do not have to be keyed in every time cc:MAIL is run. Another issue involves the cc:MAIL "popup" program (NOTIFY) which notifies users upon the arrival of new emails with a on-screen "popup" and "beep." This program requires 35 kilobytes (Kb) of memory to run as a Terminate and Stay Resident (TSR) program; users who want NOTIFY ran as a resident "popup"

should contact ITS. The installation default for NOTIFY will run it once, at user log in, to check for any unread emails; after checking for mail at log in, the program is unloaded from memory, freeing up the 35 Kb required as a TSR.

Users should be aware that a potential problem with cc:MAIL is its message storage architecture. All emails on the network are stored in one data base. On a network with 60 email users, this can create a disk storage problem since the database can conceivably grow larger than the disk partition used to store it--causing email problems. Ralston will alert all users in the event the data base is growing too large. Users cooperation in exercising good housekeeping practices with their email folders will be essential. (F. Ralston, [619] 546-7062)

PUBLICATIONS

Published

Ackman, R. G., T. Takeuchi, and G. H. Balazs. 1992. Fatty acids in depot fats of green turtles, *Chelonia mydas*, from the Hawaiian Islands and Johnston Atoll. *Comp. Biochem. Physiol.* 102B(4):813-819.

Depot fat samples from thirteen individual mid-Pacific turtles, *Chelonia mydas*, were examined for overall fatty acid composition. It can be concluded from analysis of fatty acids that the mid-Pacific green turtles generally synthesize their triglyceride depot fats with at least one, but not more than two, positions occupied by 12:0 and 14:0, possibly with 16:0 and 16:1 as well. These two fatty acids are probably utilized as temporary energy storage and are synthesized from acetate originating in the gut from dietary carbohydrates. The most probable source of dietary carbohydrate is benthic algae. These, their epiphytes, and gut bacteria also contribute numerous minor and trace unsaturated fatty acids. A select group of four oils of high iodine value (>100) are shown to have a higher-than-common concentration of 22:6n-3--22:5n-3. This suggests a particular dietary source of fatty acids different from the other samples, possibly including jellyfish or other animal matter.

Arthur, P. G., T. G. West, R. W. Brill, P. M. Schulte, and P. W. Hochachka. 1992. Recovery metabolism of skipjack tuna, *Katsuwonus pelamis*, white muscle: rapid and parallel changes in lactate and phosphocreatine after exercise. *Can. J. Zool.* 70:1230-1239.

Lactate, glycogen, and high-energy phosphate levels were measured in serial biopsies from tuna white muscle during recovery from 15 minutes of enforced

swimming. Exercise caused glycogen and phosphocreatine levels to decrease sharply and lactate concentration to increase markedly (up to $150 \mu\text{mol}\cdot\text{g}^{-1}$). Lactate was cleared from white muscle in less than 90 minutes, at rates comparable to those seen in mammals (about $1.3 \mu\text{mol}\cdot\text{g}^{-1}\cdot\text{min}^{-1}$), and this was accompanied by nearly stoichiometric increases in white muscle glycogen (2 lactate: 1 glucosyl unit). The plasma lactate concentration remained elevated (35-40 mM) until lactate clearance from white muscle was completed, whereas the level of plasma glucose was constant (12-16 mM) for the entire 3-hour recovery period. The exercise routine caused minimal changes in white muscle purine nucleotides apart from a slight, but significant, increase in IMP content. Transient changes in ATP appear to have resulted from short-term intense swimming activity noted during anesthetization. Unlike other teleosts, lactate clearance in tuna parallel creatine rephosphorylation during recovery from exercise. The authors suggest that the postexercise adjustment of intracellular pH is responsible for this relationship. Lactate was seemingly metabolized within the white muscle mass, as indicated by in situ conservation of lactate carbon apparent from stoichiometric increases in white muscle glycogen levels. This prospect is discussed in view of low estimates of lactate utilization rates by other tissues and contrasted with expected high rates of whole-body lactate turnover during recovery.

Bowen, B. W., A. B. Meylan, J. P. Ross, C. J. Limpus, G. H. Balazs, and J. C. Avise. 1992. Global population structure and natural history of the green turtle, *Chelonia mydas*, in terms of matriarchal phylogeny. *Evolution* 46(4):865-881.

To address aspects of the evolution and natural history of green turtles, the scientists assayed mitochondrial (mt) DNA genotypes from 226 specimens representing 15 major rookeries around the world. Phylogenetic analyses of these data revealed (1) a comparatively low level of mtDNA variability and a slow mtDNA evolutionary rate (relative to estimates for many other vertebrates); (2) a fundamental phylogenetic split distinguishing all green turtles in the Atlantic-Mediterranean from those in the Indian-Pacific Oceans; (3) no evidence for matrilineal distinctiveness of a commonly recognized taxonomic form in the East Pacific (the black turtle *C.m. agassizi* or *C. agassizi*); (4) in opposition to published hypotheses, a recent origin for the Ascension Island rookery, and its close genetic relationship to a geographically proximate rookery in Brazil; and (5) a geographic population substructure within each ocean basin (typically involving fixed or nearly fixed genotypic differences between nesting populations) that suggests a strong propensity for natal homing by females. Overall, the global matriarchal phylogeny of *Chelonia mydas* appears to have been shaped by both geography (ocean basin separations) and behavior (natal homing on regional or rookery-specific scales). The shallow evolutionary population structure within ocean basins

likely results from demographic turnover (extinction and colonization) of rookeries over time frames that are short by evolutionary standards but long by ecological standards.

Buck, L. T., R. W. Brill, and P. W. Hochachka. 1992. Gluconeogenesis in hepatocytes isolated from the skipjack tuna, *Katsuwonus pelamis*. *Can. J. Zool.* 70:1254-1257.

Skipjack tuna, *Katsuwonus pelamis*, hepatocytes were isolated and determined to be viable based on trypan blue exclusion, energy charge, and lactate dehydrogenase leakage. Trypan blue staining and red blood cell contamination were always less than 0.1 percent, and lactate dehydrogenase leakage remained less than 1 percent at 25°C for 10 hours. The energy charge for freshly isolated cells ranged from 0.65 to 0.74. Alanine (10 mM) gave higher rates of gluconeogenesis and oxidation than lactate: alanine rates were 3.17 ± 0.65 $\mu\text{mol glucose}/(\text{g packed cells} \cdot \text{h})$ and 9.1 ± 1.19 $\mu\text{mol CO}_2/(\text{g} \cdot \text{h})$, whereas lactate rates were 0.47 ± 0.08 and 1.8 ± 0.27 , respectively. Phosphoenolpyruvate carboxykinase was 30 percent cytosolic and 70 percent mitochondrial, a finding that is in agreement with the liver's ability to use both lactate and alanine as gluconeogenic substrates. If hepatic gluconeogenesis is the major route of lactate removal postexercise, it is estimated that recovery would require 3800 hours! Therefore, tuna liver is not the major site of glucose resynthesis and lactate clearance following burst exercise.

Farrell, A. P., P. S. Davie, C. E. Franklin, J. A. Johansen, and R. W. Brill. 1992. Cardiac physiology in tunas. I. *In vitro* perfused heart preparations from yellowfin and skipjack tunas. *Can. J. Zool.* 70:1200-1210.

An *in situ* heart preparation perfused with oxygenated saline was used to examine cardiac performances at 25°C in yellowfin tuna, *Thunnus albacares*, and skipjack tuna, *Katsuwonus pelamis*. Heart rates (91-172 beats per minute in skipjack tuna and 101-157 beats per minute in yellowfin tuna) were comparable to those measured *in vivo*, and physiological stroke volumes were possible in yellowfin tuna with subambient filling pressures. In yellowfin tuna, maximum stroke volume and cardiac output were similar to the values obtained *in vivo* with spinally blocked animals; mean output pressures (up to 145 cmH₂O, 1 cmH₂ = 0.098 kPa) could exceed *in vivo* values without a major decrease in the resting cardiac output (homeometric regulation). In contrast, saline-perfused skipjack tuna hearts could not develop physiological output pressures without compromising cardiac output, with cardiac output being only 63 percent of the *in vivo* value at an output pressure near the *in vivo* ventral aortic pressure. The poor performance of the skipjack tuna heart is attributed to limited oxygen diffusion through the thicker-walled ventricle. The authors conclude that the tuna heart is more dependent on its coronary circulation for normal function than the hearts of other fishes examined

thus far. The coronary circulation was perfused with saline at various flow rates in isolated hearts from skipjack tuna to develop a pressure-flow relationship for the intact circulation. Coronary resistance reached a minimum of 24 cmH₂O/min/g ventricular mass/mL at a flow rate of 2 mL/(min/g ventricular mass) with perfusion pressure about 40 cmH₂O. *In vivo* coronary blood flow was estimated from the pressure-flow relationship as 0.67 mL/(min/g ventricular mass). Injections of adrenaline, noradrenaline, and phenylephrine into coronary circulation under constant flow conditions increased perfusion pressure, indicating the possibility of α -adrenergic vasoconstriction.

Gerrodette, T., M. P. Craig, and T. C. Johanos. 1992. Human-assisted fostering of Hawaiian monk seal pups. *'Elepaio* 52(7):43-46.

Hiruki, L. M., and T. J. Ragen. 1992. A compilation of historical monk seal, *Monachus schauinslandi*, counts. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-172, 200 p.

The history of the Hawaiian monk seal, *Monachus schauinslandi*, is poorly known. Sources of historical data for this species are either not published or, if published, are often not readily accessible. The lack of availability of these data impedes review of past population trends, yet analysis of past trends may provide information important to current management of this endangered species. To facilitate such analysis and review, historical counts of the Hawaiian monk seal are compiled in this document. Counts are presented in tables ordered on an island-by-island or atoll-by-atoll basis; records begin in the early 1800s and continue to the early 1980s. Sources of the historical data for this species are also listed.

Keen, J. E., A. P. Farrell, G. F. Tibbits, and R. W. Brill. 1992. Cardiac physiology in tunas. II. Effect of ryanodine, calcium, and adrenaline on force-frequency relationships in atrial strips from skipjack tuna, *Katsuwonus pelamis*. *Can. J. Zool.* 70:1211-1217.

Force-frequency relationships and the dependence upon extracellular calcium as a source of activator calcium were investigated using atrial strips from the skipjack tuna, *Katsuwonus pelamis*. At 25°C, active force generation increased over a stimulation range of 0.2-1.6 Hz and declined at higher stimulation frequencies. Ryanodine, a blocker of calcium release from the sarcoplasmic reticulum, decreased active force by ~30 percent but did not alter the shape of the force-frequency curve. Uniform contractions were maintained up to stimulation rates of 3.0 Hz following ryanodine application, compared with 3.4 Hz under control conditions. Active force increased with increasing extracellular calcium concentration in a concentration-dependent manner with greatest sensitivity over the range of 1.0-5.0 mM calcium. Activation duration decreased with increasing extracellular calcium concentrations up to 5.0 mM and with increasing contraction frequency up to 1.0 Hz. Relaxation

duration also was reduced with increasing extracellular calcium over a range of 0.5-4.0 mM, and over a stimulation range of 0.2-0.6 Hz. Adrenaline increased active force threefold over the range of 10^{-8} to 10^{-5} M, with an EC_{50} value of $4.90 \pm 0.57 \times 10^{-7}$ M. The EC_{50} value was not dependent upon stimulation frequency. These results indicate that contraction in the skipjack tuna atrium is partially dependent upon intracellular calcium release from the sarcoplasmic reticulum. In this manner, the tuna heart more closely resembles the mammalian model of excitation-contraction coupling than that suggested for other fishes in which activator calcium is almost exclusively derived from extracellular influx.

Kusher, D. I., S. E. Smith, and G. M. Cailliet. 1992. Validated age and growth of the leopard shark, *Triakis semifasciata*, with comments on reproduction. *Environ. Biol. Fishes* 35:187-203.

The age, growth, and sexual maturation of the leopard shark, *Triakis semifasciata*, from central California were studied. Growth band counts in vertebral centra of 162 leopard sharks produced von Bertalanffy growth curves with L_{∞} , K, and t_0 parameters of 1536 mm 0.082, and -2.31, respectively, for both sexes combined. The L_{∞} value for females (1602 mm TL) was slightly but insignificantly higher than for males (1499 mm TL), but the K and t_0 values were almost identical. Seasonal changes in size modes of young-of-the year leopard sharks, centrum edge characteristics, and growth and tetracycline mark-recapture from the field were used to validate annual deposition of vertebral centrum band pairs. Sexual maturity was evaluated by the gonads and presence of sperm and eggs; males mature at 7 years and at about 63 percent of asymptotic length, and females mature at 10 years, and at about 72 percent of asymptotic length. This slow growth, late maturity, and relatively low fecundity may increase their susceptibility to over-exploitation.

Lo, N. C. H., J. R. Hunter, H. G. Moser, P. E. Smith, and R. D. Methot. 1992. The daily fecundity reduction method: a new procedure for estimating adult fish biomass. *ICES J. mar. Sci.* 49:209-215.

A new method was developed for estimating adult fish biomass from the daily decline in reproductive potential of the population and the numbers of planktonic eggs. Decline in reproductive potential was estimated from the product of the daily decline in the standing stock of advanced oocytes in ovaries and the daily decline in the numbers of females with reproductively active ovaries. Daily production of planktonic eggs was estimated from the number of eggs in quantitative oblique plankton tows. The method is restricted to fishes in which the potential annual fecundity becomes fixed prior to the onset of the spawning season, that is, fishes with determinate annual fecundity. The method was applied to data for *Microstomus pacificus*, commonly known as Dover sole, a pleuronectid flatfish of the upper continental shelf (200-1500 m) of the west coast of North America.

Mathieu-Costello O., P. J. Agey, R. B. Lodgeman, R. W. Brill, and P. W. Hochachka. 1992. Capillary-fiber geometrical relationships in tuna red muscle. *Can. J. Zool.* 70:1218-1229.

The aim of this study was to examine the size and geometry of the capillary network in tuna red muscle, one of the most aerobic muscles in fish. Deep red muscle of 1.5- to 2-kg skipjack tuna, *Katsuwonus pelamis*, was perfusion fixed in situ, processed for electron microscopy, and analyzed by morphometry. Fiber cross-sectional area was 560 ± 30 (SE) μm^2 in the samples. Capillary length per fiber volume was 4143 ± 242 (SE) mm^{-2} and mitochondrial volume density 28.5 ± 1.0 (SE) percent. Indexes of capillarity such as average number of capillaries around a fiber, capillary length and surface per fiber volume, and capillary surface per fiber surface were high for a fish muscle. In fact, the size of the capillary-fiber interface (i.e., capillary to fiber surface) at a given mitochondrial volume per fiber was not significantly different in tuna red muscle compared with rat soleus muscle. However, calculation of mitochondrial respiratory rates in tuna red muscle yielded a substantially lower value (approximately 1/20th) compared with muscles of mammals. Besides the possible effect of differences in operating temperatures and (or) mitochondrial function(s) in fish compared with mammals, this suggests that the large capillary-fiber interface in tuna may be related to functions other than oxygen delivery per se, such as substrate and (or) heat transfer between capillaries and muscle fiber.

Moser, H. G., and W. Watson. 1992. Distribution and abundance of early life history stages of the California halibut, *Paralichthys californicus*, and comparison with the fantail, *Xystreurys liolepis*. *Fish. Bull., U.S.* 174:31-84.

Temporal and spatial abundance patterns of the larvae of two paralichthyid flatfishes, California halibut, *Paralichthys californicus*, and fantail sole, *Xystreurys liolepis*, were investigated using a 30-year-long (1951-81) California Cooperative Oceanic Fisheries Investigations (CalCOFI) data set that included stations from central California to southern Baja California, and an 8-year-long (1978-86) nearshore data set from two sites in the vicinity of San Onofre, California.

California halibut spawn throughout the year, primarily in February-March and secondarily between July and October off California and northern Baja California. Further south, in Sebastian Viscaïno Bay and off central and southern Baja California, spawning is primarily in June-August, and secondarily in February-March. Most larvae occur over the continental shelf, in the upper 30 m of the water column. The oldest larvae occur almost exclusively very near shore; at night they are neustonic. The surfaceward movement of older larvae may facilitate their movement to the shallow zone where they settle and transform to the juvenile stage.

Abundance of larval California halibut is highest off southern California, northern Baja California, and in Sebastian Viscaïno Bay, and lowest off central California and southern Baja California. Interannual patterns of larval abundance and the California commercial catch have been highly concordant since 1958, suggesting that the year-to-year fluctuations in the commercial catch result largely from halibut abundance. Furthermore, this concordance of interannual patterns suggests that ichthyoplankton surveys can be used as fishery-independent tool to assess and monitor the spawning biomass of California halibut.

Fantail sole spawn throughout the year, with most activity in the last half of the year (August-December). Larvae occur primarily over the continental shelf, mainly off Baja California. Preflexion and flexion stage larvae occur principally in the midwater column; postflexion stage larvae settle into the moderately shallow (22-45 m) epibenthos where they transform to the juvenile stage. The different benthic recruitment strategies of fantail sole and California halibut minimize trophic competition between the young juveniles of the two species.

Moyes, C. D., O. A. Mathieu-Costello, R. W. Brill, and P. W. Hochachka. 1992. Mitochondrial metabolism of cardiac and skeletal muscles from a fast *Katsuwonus pelamis* and a slow *Cyprinus carpio* fish. *Can. J. Zool.* 70:1246-1253.

Tuna cardiac (atrium, compact and spongy ventricle) and skeletal muscle (red and white) were compared with carp tissues to determine the importance of mitochondrial differences in supporting the high aerobic capacities in tuna. Mitochondria isolated from red muscle of both species oxidized each of the physiological fuels at similar rates per milligram of mitochondrial protein, when differences in assay temperature are considered. The highest rate of oxygen consumption by ventricle mitochondria was 2 times greater in tuna than carp. The maximal oxidation rates were 3-4 times higher in ventricle than red muscle in both species. Tuna tissues had as much as 30-80 percent more mitochondrial protein per gram of tissue than carp. Morphometrically this was manifested as extremely densely packed mitochondrial cristae, rather than increased mitochondrial volume densities. In general, higher aerobic capacities of tuna ventricle and red muscle are primarily attributable to greater tissue mass and, to a lesser extent, differences in the nature or quantity of mitochondria per gram of tissue. Unlike ventricle and red muscle, tissues with relatively low mitochondrial contents in carp (white muscle, atrium) demonstrated several-fold higher mitochondrial contents in tuna. Enzyme analyses of tissue and isolated mitochondria suggest a greater dependence of tuna tissues on fatty acids as fuels. Activities of carnitine palmitoyl transferase (CPT) per milligram of protein were 2-2.5 times higher in tuna red muscle and ventricle mitochondria than in carp mitochondria from the same tissues. Whole tissue activity ratios of hexoki-

nase/CPT, which indicate the relative importance of glucose and fatty acid metabolism, were 5 times higher in carp spongy ventricle and 12 times higher in carp compact ventricle. These data suggest that muscle aerobic capacity can be increased at several levels: tissue mass, mitochondrial volume density, cristae surface density, and mitochondrial specific activity. Large differences observed between carp and tuna muscles are due to cumulative effects of several of these factors.

Tibbits, G. F., H. Kashiwara, and R. W. Brill. 1992. Myocardial sarcolemma isolated from skipjack tuna, *Katsuwonus pelamis*. *Can. J. Zool.* 70:1240-1245.

The high cardiac outputs observed in tuna compared with other teleosts may imply differences in the regulation of myocardial contractility. Sarcolemma is a critical organelle in the teleost heart in the regulation of intracellular calcium concentration and hence contractility. A procedure is described for the isolation of large quantities of highly purified sarcolemma from the skipjack tuna heart by differential and sucrose-gradient centrifugation in the presence of multiple protease inhibitors. The preparation was characterized using the sarcolemma marker K^+ -stimulated *p*-nitrophenylphosphatase ($K^+pNPPase$). From a starting ventricular wet weight of about 60 g, a yield of >20 mg sarcolemmal protein and a >43-fold purification over the crude homogenate were achieved. The percentage recovery of the total $K^+pNPPase$ in the sarcolemma fraction was greater than 14 percent. Both the purification index and recovery were substantially greater than those achieved with a much smaller scale sarcolemma preparation recently described for the trout heart. The equilibrium binding of the dihydropyridine PN200-110 and ryanodine were determined in these preparations. In purified sarcolemma, the dihydropyridine receptor binding density (B_{max}) and dissociation constant (K_d) were found to be 0.48 ± 0.07 pmol•mg protein⁻¹ and 0.09 nM respectively, similar to that found in mammals. In crude homogenates, the ryanodine receptor B_{max} was approximately 0.12 ± 0.04 pmol•mg protein⁻¹ and thus was a little more than half the value observed for the dihydropyridine receptor. The large-scale sarcolemma isolation procedure described in this paper for tuna may be useful for developing a better understanding of the role of the sarcolemma in the regulation of ventricular function in teleosts.

Approved by Science and Research Director, SWR

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Administrative Reports

Administrative Reports are strictly for internal use only and are not to be cited or treated as publications.

La Jolla

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Honolulu

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